GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION
SPONSORED PROJECT INITIATION

no acct
acct

Date: 1/12/79

Project Title: State Transportation Surveillance Program (Radiological Material)

Project No: B-10-659 Green Card

Project Director: M. W. Carter

Sponsor: Georgia Dept. of Human Resources (Radiological Health)

Agreement Period: From 10/1/78 Until 9/30/79

Type Agreement: Contract No. 427-93-90634

Amount: $21,000 DHR Funds
10,150 GIT cost-sharing (B-10-321)
$31,150 Total

Reports Required: Quarterly Progress Report; Expenditure; Equipment; & In-Kind Match Rep
Annual Progress Report; Annual Equipment Inventory

Sponsor Contact Person (s):

Technical Matters

Contractual Matters
(thru OCA)

Mr. Charles F. Tedford
Radiological Health Unit
Ga. Dept. of Human Resources
State Office Building
4[illegible] Trinity Avenue
Atlanta, GA 30334

894-5795

Defense Priority Rating: n/a

Assigned to: OIP (School/Laboratory)

COPIES TO:

Project Director
Division Chief (EES)
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Project File (OCA)
Project Code (GTRI)
Other

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION

Date: 8/6/80

Project Title: State Transportation Surveillance Program (Radiological Material)

Project No: B-10-659

Project Director: M. W. Carter

Sponsor: Georgia Dept. of Human Resources (Radiological Health)

Effective Termination Date: 6/30/80

Clearance of Accounting Charges: 6/30/80

Grant/Contract Closeout Actions Remaining: none

_ Final Invoice and Closing Documents
_ Final Fiscal Report
_ Final Report of Inventions
_ Govt. Property Inventory & Related Certificate
_ Classified Material Certificate
_ Other _____

Note: Project Transferred to Nuclear Engineering to be contined as E-26-65

Assigned to: OIP (School/Laboratory)

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CA–4 (1/79)

12-10-78

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF INTERDISCIPLINARY PROGRAMS
205 OLD CIVIL ENGINEERING BUILDING
ATLANTA, GEORGIA 30332

ENVIRONMENTAL RESOURCES CENTER
(404) 894-2375

BIOENGINEERING CENTER
(404) 894-2375

MEMORANDUM

DATE: January 31, 1979

TO: Chief, Radiological Health Unit
Georgia Department of Human Resources Attn: Willard Ingram

FROM: Bernd Kahn, Director [redacted]
Environmental Resources Center

SUBJECT: First Quarterly Report of Progress (October 1-December 31, 1978) of Extended State Transportation Surveillance Program - Radioactive Materials - under agreement between Georgia Department of Human Resources and Georgia Institute of Technology

In this 1-year extension of the study of the transportation of radioactive materials in Georgia, special emphasis will be placed on techniques for reducing radiation exposures to handlers of radioactive packages and delineating the extent of multicurie shipments throughout the State. The preceding study had shown no personnel exposures in excess of 500 mR/yr in selected measurements at RAM package carriers but suggested the need for detailed and systematic personnel exposure rate determinations to confirm that values were below this limit. The potential exists for reducing exposure rates in package handling, particularly by truck drivers, through appropriate RAM package placement and shielding. The previous study had also indicated frequent shipments of multicurie materials related to the nuclear fuel cycle -- especially radioactive wastes transported by truck to the waste repository at Barnwell, S.C. The monitored shipments consistently showed low external radiation exposures, but it appeared desirable to obtain further information concerning the origins, destinations, frequency, and types of shipments on a current basis.

The first quarter of this study was devoted to a large degree to determining radiation exposures at RAM carrier terminals. The placement of thermoluminescent dosimeters (TLD's) at RAM storage sites and control points for 3-month periods during the preceding study was continued to complete a full year of measurements, as indicated in Table 1. The highest reading during this quarter was 1,030 mR at a RAM storage location at the Purolator terminal. Levels above the background radiation exposure of approximately 11 to 25 mR/quarter were found at several other locations, but none of these suggested the potential for very high personnel exposures.

A second set of quarterly TLD measurements of terminal workers and truck drivers was obtained as shown in Table 2. The highest value, of 580 mR/quarter, was for TLD's issued to a driver who had affixed the dosimeters to his truck. A number of other TLD's showed elevated readings, including one of 160 and one of 120 mR/quarter. The appropriate utilization of these dosimeters is open to question, however, because some were observed not to be worn, and others were not issued by the supervisor or not returned. More consistent use of dosimeters was encouraged by discussion with supervisors and change to monthly collection. The results of the first monthly collection are shown in the last column of Table 2. The highest exposure rate was 150 mR/month, as a result of which it was arranged that the driver subsequently drove a larger truck to permit increasing the distance between himself and high-TI packages.

Thermoluminescent dosimeters were placed in vehicles behind the drivers' seats, 12 inches above the seat, to indicate the truck routes on which drivers could receive significantly elevated exposures. The results for the first month in Table 3 show exposures of several hundred mR/month on the truck carrying Mallinckrodt packages from St. Louis to Atlanta and two courier trucks, one on a route between Atlanta and Chattanooga and the other picking up NEN packages delivered by chartered flight to the Atlanta airport. Interpretation of these data in terms of exposure to a driver or per route is not yet possible for the courier trucks because both vehicles and drivers were periodically reassigned.

Frequent field trips were undertaken to RAM carrier terminals to observe handling of RAM and obtain information on shipments. Monitored RAM packages are summarized in Table 4. Observations are discussed in Appendix A. Of the wipes obtained, those shown in Table 5 contained detectable contamination.

A second chartered truck began delivering radiopharmaceutical packages to the Purolator terminal each weekend, this one carrying RAM from Squibb in Brunswick, New Jersey. Chartered flight deliveries of NEN radiopharmaceuticals from Newark now arrive more often at Charlie Brown airport than at Atlanta airport because of the increased landing fee at the latter; the driving time of the truck from the Charlie Brown airport to Purolator terminal is approximately 20 minutes, compared to 15 minutes from Atlanta Airport. Two trucks are being used on this run, however, to reduce exposure to the driver. The radiation levels due to the radiopharmaceutical packages from the two trucks and plane observed on the chartered truck for Mallinckrodt RAM from St. Louis and on some courier trucks to which they were transferred during three weekends is shown in Appendix B. The packages in these shipments are described in Table 6. Several drivers were assisted in loading RAM packages so as to minimize the dose to the driver. Results of wipes that showed contamination are given in Table 5.

During the next quarter year of the study, further efforts will be made to determine radiation exposures to drivers and also to develop approaches for reducing such exposures. Collection of detailed information concerning nuclear fuel cycle shipments will also be expanded from the data base obtained in the initial study.

Table 1

Site Monitoring with TLD's

TLD LOCATION		Quarterly Exposure, mR 11/3/77 to 2/2/78	2/2/78 to 5/8/78	5/8/78 to 8/7/78	8/7/78 to 11/6/78	Annual Exposure, mR
Federal Express						
C	- Office	27	37	24	25	110
C	- Whse	22	36	---	---	---
	- RAM area	290*	220	53	50	---
	- RAM area	M	46	---	---	---
Shulman Air Express						
C	- Office	22	30	†	---	---
C	- Office	23	26	---	---	---
	- RAM area	210	28	---	---	---
	- Time clock (RAM in vicinity)	60	48	---	---	---
Delta Cargo Terminal						
C	- North wall	44	50	29	36	160
C	- East wall	32	13	34	37	120
	- Inbound RAM area	250	74	M	210	---
	- Outbound RAM area	34	M	23	23	---
Spare 1	- Shelf (inbound, not designated hazardous)	750	1,090	500	220††	2,600
Purolator Terminal						
C	- Office	34	39	32	42	150
C	- Store room	43	50	20	25	140
	- Dispatcher's window	M	160	110	160	---
	- North wall, middle	410	410	280	360	1,460
	- South wall, exit route	1,030	2,380	600	590	4,600
	- South wall, load'g zone	490	390	310	540	1,700
	- North wall	---	2,390**	M	1,030	---
Emery Air Freight						
C	- Office	---	20	---	---	---
C	- Office	---	15	14	14	---
	- RAM area (center)	---	53	19	55	---
	- RAM area (left edge)	---	40	---	---	---
Air Lift International						
C	- Office, Operations	---	27	24	22#	---
C	- Office	---	24	---	---	---
	- RAM area	---	25	---	150##	---
	- RAM area	---	74	21	24#	---

Table 1 (cont'd)

TLD LOCATION		Quarterly Exposure, mR 11/3/77 to 2/2/78	2/2/78 to 5/8/78	5/8/78 to 8/7/78	8/7/78 to 11/6/78	Annual Exposure, mR
Air Lift International (new building) ###						
L C	- Office	---	---	---	11	---
2 C	- Break Room	---	---	---	13	---
3	- RAM area	---	---	---	23	---
4	- RAM area	---	---	---	29	---
5	- RAM area	---	---	---	36	---
Eastern Airline Cargo Terminal						
8	- Office	---	77***	73***	73***	---
9 C	- Cargo area, no RAM	---	M	14	16	---
0	- RAM area, outbound	---	17	18	14	---
.	- RAM area	---	140	200	41	---
2	- RAM area (terminating area)	---	66	34	43	---
Spare 'A'	- RAM area (terminating area)	---	---	---	32	---
Spare 'B'	- Cooler wall	---	---	---	88***	---
Flying Tigers						
1 C	- Office	---	---	23	22	---
.	- RAM area	---	---	33	50	---

Notes: C denotes Control TLD's

M denotes missing

* TLD was originally positioned adjacent to the RAM packages under the rollers; when the area was repainted, TLD was positioned on the office side instead of the RAM side for several weeks before retrieval date.

** TLD was positioned in a new work area in which a RAM package (Ir-192, 94.5 mCi, TI 1.0) was held pending disposition instructions. Package was seen on January 19 and again on March 9, 1978.

*** Elevated reading due to concrete block materials of wall.

† TLD's not positioned because company planned to move May 15, 1978.

†† TLD attached to rack which was repositioned to non-RAM area 3-4 weeks before retrieval.

\# At location 8/7/78 to 10/15/78 (company moved 10/10/78).

\## At new RAM location opposite side of terminal from 8/16/78 to 10/15/78.

New building 10/16/78 to 11/6/78.

TABLE 2

Personnel TLD Monitoring

		Exposure rate, mR/period		
		5/11/78 to 8/9/78	8/16/78 to 11/15/78	11/15/78 to 12/15/78
Purolator, Atlanta				
	Control TLD	25	57	16 (4)
1	Office Secretary/telephone operator	71	36	8
2	Driver - Atlanta to Montgomery, AL (Rt 028)	59	69	16 (5)
3	Driver - Atlanta to Montgomery, AL (Rt 028, Sunday)	42	160	150 (6)
4	Driver - Atlanta to Macon, GA (Rt 039)	33	65	10.4
5	Dirver - Atlanta area (Rt 024)	31	60	8.7
6	Driver - Atlanta to Chattanooga, TN (Rt 014)	39	60 (1)	14
7	Weekend Dispatcher	32	87	38
8	Driver - Atlanta to Charlotte, NC (Rt 018 part time) & Orlando, FL	101	120	16
9	Driver - Atlanta to Charlotte, NC (Rt 018)	32	580 (2)	80
10	Driver - Atlanta area (Rt 068)	70	78	NR
11	Driver - Atlanta Airport (Rt 035 weekdays)	NR*	64	17 (12)
12	Courier Terminal Sorter	40	NR	17 (12)
13	Courier Terminal Sorter	NR	53	14
14	Dispatcher	39	56	19
15	Terminal Sorter		NR	10.6
16	Terminal Sorter		55 (3)	NR
17	Driver - Atlanta to Montgomery, AL (Rt 028)		59 (7)	16 (7)
18	Terminal Van Loader			5.1 (8)
26	Driver - Memphis to Atlanta (Mallinckrodt RAM chartered truck)			NR
28	Driver (Atlanta Airport Rt 086 - NEN RAM weekend)			NR

* NR: not recovered

Table 2 (cont'd)

		Exposure rate, mR/period		
		5/11/78 to 8/9/78	8/16/78 to 11/15/78	11/15/78 to 12/15/78
Eastern Cargo Terminal				
1	Ramp service (0800-1630 hrs)			6.2
2	Ramp service (1620-0020 hrs)			5.7
3	Ramp service (0010-0810 hrs)			5.8
4	Supervisor (0800-1700)			7.1
Federal Express				
	Control TLD	23	27	---
1	Customer Service Agent (CSA) at counter	28	NR	6.7
2	Cargo Handler	27	NR	5.0
3	Night Supervisor	28	28	NR
4	Driver (Pick up RAM GA Tech)	---	---	NR
Delta Cargo Terminal**				
	Control TLD	30	25	8.7
1	(B) Sr Air Frt Uniform Sales Clerk (office 2nd floor)	17	26	8.8 (9)
2	(C) SCSA Special Service Agent	24	23	6.7
3	(C) CSA Add-TO/Special Service & inbound	29	24	4.4
4	(C) SCSA Delivery	30	24	7.7
5	(C) SCSA inbound	NR	25	5.1
6	(A) CSA Floor	26	24	8.2 (10)
7	(A) CSA Add-To	30	NR	8.0 (10)
8	(A) CSA Sorter	25	25	8.0 (10)
9	(A) CSA Special Service Agent	28	25	6.2 (10)
10	(D) SCSA Floor	30	25	5.7
11	(D) SCSA Special Service Agent	25	19	6.3
12	(D) SCSA Special Cargo	NR	24	NR (11)
13	(D) SCSA Sorting Area	28	24	6.0

NOTES: (1) For two month period (August 16 to October 16).

(2) Retrieved on November 30, 1978 from truck 15195. Driver would wear TLD while loading and then attach TLD to wire partition (screen) between driver's seat and RAM cargo while working on non-RAM.

Table 2 (cont'd)

(3) For two-month period (man terminated job mid-October 1978).

(4) Control TLD was located in Dispatcher's office under counter.

(5) TLD was not worn by individual due to misunderstanding and TLD remained in TLD box with instruction sheet.

(6) Driver stated that RAM was loaded in front of vehicle (a small van) before December 17, 1978; a large truck thereafter was used, and non-RAM was loaded for first 7 feet behind driver, after the need for distance between RAM and driver had been stressed.

(7) Duplicate for TLD #3, but driver never wore #17. TLD #17 was still attached to instruction sheet in TLD box.

(8) TLD was never worn while working in terminal (no wallet), according to discussion with person.

(9) Not known if TLD was worn, due to hospitalization of worker. TLD was in TLD box.

(10) TLD's allotted to midnight shift were never issued to personnel and remained in supervisor's office during subject period.

(11) Individual transferred to ticket counter at main terminal.

(12) TLD not used. TLD was still attached to instruction sheet.

* NR: not recovered.

** Shift: (A) 2315-0700
(B) 0800-1700
(C) 1500-2330
(D) 0700-1515

TABLE 3

Exposure Rates in Vehicles

TLD #	Vehicle #	Route	Exposure, mR/month 11/15/78 to 12/15/78
Purolator*			
19	15194	Atlanta to Chattanooga (express) (Rt 014) (vehicle used on Rt 018 - Charlotte - on November 18, 1978)	310
20	15170	Atlanta to Macon (Rt 039)	7.6
21	16111	Birmingham to Atlanta	38
24		Birmingham to Atlanta (duplicate of #21)	36
22	15181	Atlanta to Montgomery (express) (Rt 028)	61
23	37064	Atlanta to Augusta (Rt 064) (vehicle used on December 14, 1978 to Birmingham, AL)	34
25	15165	Atlanta area (Rt 024)	81
27	61663	St. Louis, Memphis, Birmingham, Atlanta, to Orlando, FL (lead shield installed)	420
29	15201	Atlanta Airport (Rt 086) (TLD behind driver's seat)	190
30		(TLD under right side of driver's seat)	94
31	16144	Montgomery to Atlanta (Rt 028)	16
Federal Express			
5	162024	(Atlanta to Georgia Tech route)	6.1

* Vehicles may be substituted on different routes due to breakdown. Vehicles shown were on route when TLD was installed.

TABLE 4

Monitored RAM Packages

te	Location	Amount, Ci	Isotopes	Transportation Index	Exempt	I	II	III	Remarks
tober 1978									
	J	1.7	Mo-99	2.5	---	-	--	1	out
	J	1.7	Mo-99	2.5	---	-	--	1	out
	J	1.7 (1.33 on freight bill)	Mo-99	2.5	---	-	--	1	out
	J	1.1	Mo-99	1.6	---	-	--	1	out
	A	96,100	Tritium (H3-P)	---	---	-	--	1	out
vember 1978									
	J	1.8 (1.33 on freight bill)	Mo-99	2.5	---	-	--	1	out
	J	1.7 (1.33 on freight bill)	Mo-99	2.5	---	-	--	1	out
	J	1.1	Mo-99	1.6	---	-	--	1	out
	J	0.0077 (0.00647 on freight bill)	I-131	1.7	---	-	--	1	out
:ember 1978									
	J	0.003	Ga-67	0.1	---	-	1	-	out
	J	1.7	Mo-99	2.5	---	-	--	1	out
	J	2.8	Mo-99	2.9	---	-	--	1	in

e: Location A: Aiborne Freight; J: Purolator Courier Corporation.

TABLE 5

Radionuclides on Wipes

Date, 1978	Surface wiped	Radionuclide	Concentration, pCi/100cm^2
Trucks			
October 14	61663 Ryder truck, rear of bed	Se-75 I-131	0.5 1.2
November 18	same as above	Se-75	5.8
November 18	steering wheel	Se-75	0.315
December 16	61663 Ryder truck, rear of bed	Se-75	1.8
RAM packages			
October 15	tritium drum USA/6678/BL	H-3	0.22
November 18	Squibb (4)	Se-75	0.31
December 19	Squibb generator	Se-75 I-131 Mo-99	0.088 0.12 4.2

Note: No other photon-emitting radionuclides were detected.

TABLE 6

Summary of Weekend RAM Shipments Distribution by Purolator Courier,
Atlanta, Georgia from New England Nuclear (NEN), Mallinckrodt (M) and Squibb (SQ)

1978 Date	Source	Destination	I-131	Mo-99	Misc.	Activity, curie	TI	Ltd.	Category I	Category II	Category III	Unk.	Totals
October 14	NEN	AL	1	9	14	9.6	30.2	1	10	5	8	--	24
December 16			--	9	21	11.8	35.8	2	12	7	9	--	30
October 14		FL*	--	2	1	3.2	9.0	--	1	--	2	--	3
December 16			--	1	--	1.3	4.0	--	--	--	1	--	1
October 14		GA	--	15	20	17.5	55.2	1	13	4	17	--	35
December 16			--	18	21	18.9	59.0	4	12	5	18	--	39
October 14	M	NC	--	37	7	33.0	46.3	3	2	2	37	--	44
November 18			23	33	1	28.5	44.5	1	0	22	34	--	57
December 16			22	32	1	27.0	41.5	--	--	3	52	--	55
October 14		FL	14	52	3	68.1	92.9	1	--	15	53	--	69
November 18			3	54	1	75.7	101.6	--	1	1	56	--	58
December 16			3	54	1	71.7	122.8	--	--	2	56	--	58
October 14	M	GA	4	17	--	13.5	21.2	--	--	3	18	--	21
November 18			2	19	2	19.8	30.0	--	--	2	21	--	23
December 16			11	19	1	19.5	28.2	--	--	11	20	--	31
October 14	SQ	TN	1	2	1	3.4	6.7	1	--	--	3	--	4
November 18			2	4	1	5.6	11.1	1	--	1	5	--	7
December 16			2	6	1	7.5	14.4	1	--	2	6	--	9
October 14		AL	5	21	4	30.4	46.1	--	--	5	21	4	30
November 18			6	19	2	27.7	46.8	--	--	5	22	--	27

TABLE 6 (cont'd)

1978 Date	Source	Destination	I-131	Mo-99	Misc.	Activity, curie	TI	Ltd.	Category I	Category II	Category III	Unk.	Totals
December 16			2	18	--	26.9	40.8	--	--	1	19	--	20
October 14		FL*	--	4	--	5.0	8.2	--	--	--	4	--	4
November 18			--	4	--	5.0	8.2	--	--	--	4	--	4
December 16			--	5	--	5.4	8.8	--	--	--	5	--	5
October 14	SQ	GA	4	16	1	20.0	34.4	--	--	3	18	--	21
November 18			7	14	--	34.3	33.7	--	--	2	19	--	21
December 16			3	13	4	18.9	30.7	2	--	3	15	--	20

* RAM packages routed through Montgomery, AL for Pensacola/Panama City, FL.

Appendix A

Observations and Comments Concerning RAM Package Shipments

1. On October 13, 1978, Radiological Health Unit staff provided the information that a Mo-99 generator shipped through Atlanta had a reading of 30-50 mR/hr when monitored by a Chattanooga hospital. Subsequent telephone conversations with Radiological Health staff in Tennessee indicated that the generator was from Squibb, bill number 31235G with a TI of 1.6, activity of 800 mCurie on October 10, 1978. A part of the lead shield may have been missing.

2. On October 13, 1978, Radiological Health Unit staff provided the information that a container of 96,086 curies H-3 (as HT) had a hole and that no TI were indicated. The container was monitored on October 15, 1978. Surface contamination was slight (see Table 5). It was noted that:
   Security seal was broken.
   One yellow III label was completely blank and the other had a dash (-) for TI.
   A 0.25-inch diameter hole was on the side of the container below the locking ring, and 3 other holes were covered with lead-back tape.

3. Wipes from rear of bed of Ryder truck 61663 collected on October 14, 1978, November 18, 1978 and December 16, 1978 showed detectable levels of Se-75 (see Table 5).

4. Wipes of four Squibb RAM packages collected on November 18, 1978 and one Squibb package collected on December 19, 1978 showed detectable levels of radioactivity (see Table 5).

5. Of 15 vehicles in which radiation exposures were measured in the cab, 10 vehicles had over 2 mR/hr.

6. Of 13 vehicles (not including exclusive use vehicles) in which the TI was known, 3 vehicles had over 50 TI per load.

7. All 16 vehicles that were checked had placards, except that one vehicle had one placard missing.

8. At least 4 vehicles (not exclusive use vehicles) did not maintain the minimum distance between RAM yellow II or III packages and the driver.

9. On December 17, 1978, a group of RAM packages from Squibb with TI over 50 at the Purolator terminal was not separated by 20 feet from RAM in an adjacent stack from New England Nuclear.

10. Of 18 yellow III labels on overpack boxes containing Mo-99 generators, decimal points were missing from the number of curies or in the TI in 26 instances. This shipment arrived on Delta Airlines on December 14, 1978.

Appendix B

Vehicle Monitoring Results

te	Location	Vehicle #	Route	Radiation levels, mR/hour Cab	Surface	Six ft	Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards	Remar
ctober 1978												
4	J	61663	St. Louis to A*	3.4	57	14.0	160.4	Se-75, I-131	rear 3/4	yes	yes	(a)
4	J	15195	018	10.5	44	5.2	46.3	none	middle	yes	yes	3(b
4	J	61663	A to Orlando	1.8	48	11.2	92.9	none	rear 3/4	yes	yes	(a)
4	J	15203	086	28	38	5.6	94.4	none	full	yes	yes	1(b
ovember 1978												
8	J	61663	St. Louis to A	4.9	80	13.5	176.1	Se-75	rear 3/4	yes	yes	(a)
8	J	61663	A to Orlando	2.5	80	14.0	101.6	Se-75	middle	yes	yes	(a)
8	J	15194	018	15.5	34	4.9	50.9	none	front	yes	yes	0(b
ecember 1978												
4	J	15149	035	unk	unk	unk	27.2	unk	rear	yes	unk	7(b
4	J	37064	A to Birmingham	unk	unk	unk	8.8	unk	rear	yes	unk	<7(b
4	J	15181	028	unk	unk	unk	17.6	unk	right rear	yes	unk	<7(b
4	J	56078	039	unk	unk	unk	5.6	unk	left rear	yes	unk	<7(b
4	J	15207	014	unk	unk	unk	unk	unk	unk	unk	yes	---
6	J	61663	A to Orlando	1.8	80	14.0	122.8	Se-75	rear 3/4	yes	yes	(a)
6	J	37064	018	6.3	40	4.9	41.5	none	full	yes	yes	4(b
6	J	15200	086	7	19	unk	unk (c)	unk	full	---	yes	2(b

Date	Location	Vehicle #	Route	Radiation levels, mrem/hr Cab	Surface	Six ft	Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards	Rema
16	J	15201	086	14 (d)	unk	unk	unk (c)	unk	full	---	yes	1(
17	J	15181	028	2.5	44	unk	93.2	unk	rear	yes	1 missing	7(
17	J	16705	039	0.5	14	3	35.8	unk	rear	yes	yes	6(
17	J	15180	014	0.2	14.5	unk	16.9	unk	rear	unk	yes	6(
19	J	16144	028	unk	unk	unk	0.1	unk	right rear	yes	unk	--
19	J	15207	014	0.2	2.8	2.2	3.2	unk	left rear	unk	yes	11(

NOTES: (a) lead shield installed.

(b) indicated distance in feet of non-RAM or void in space behind driver.

(c) TI 98.8 for New England Nuclear RAM loaded on two vans this weekend. Unknown what portion of TI was on which vehicle. RAM arrived Charlie Brown Airport by Baltimore Airways.

(d) Reading includes dose from stack of Mallinckrodt Mo-99 generators in vicinity.

* A indicates Atlanta.

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TO: Mr. Henry Copeland, Ac
Radiological Health Ur ard Ingram

FROM: Bernd Kahn, Director
Environmental Resourc

SUBJECT: Fourth Quarterly Repo)0,
1979) of Extended Sta ·am
- Radioactive Materia a
Department of Human Resources and ... echnology

Measurements with thermoluminescent dosimeters of radiation exposures from transporting RAM were continued for four-week intervals and will continue until data are compiled for a full year. The results for the entire period will be summarized in the annual report. Dosimeters were given to RAM handlers, placed behind the drivers' seats of vans and trucks that transported RAM on a regular basis, and located at terminals where RAM were shipped and stored. The personnel dosimeters provide a record of exposures by several groups of RAM handlers, although the data must be carefully evaluated because some of the handlers did not wear the dosimeters in a consistent or reliable manner. The results from dosimeters placed in trucks and terminals provide means of checking some of the personnel dosimetry results.

Packages of RAM were monitored as indicated in Table 1, and vehicle monitoring is summarized in Table 2. The RAM packages and RAM-carrying vehicles were monitored at the Purolator terminal except as otherwise indicated in Table 1. Problems and violations are recorded in the notes to Table 2 and in the Appendix.

More detailed information on the extent of RAM transport by airlines and airfreight carriers at the Atlanta airport was compiled from airbills at carrier offices and is presented in Tables 3 - 10. The RAM transported by Eastern and Republic Airlines are radiopharmaceuticals, while the airfreight carriers also transported industrial and research radioisotopes. The two airlines and the trucking firm listed in Table 11 showed no transport of RAM in the indicated periods.

Additional information concerning the transport of radioactive waste through Georgia to the Barnwell, SC waste burial site was collected to expand the data base given in the previous Quarterly Report. Radioactive waste shipments from nuclear power stations are listed in Table 12, and shipments from all other sources, in Table 13. The typical shipment from nuclear power stations contains approximately 20 Ci; shipments from other locations had extremely small curie values except for two shipments of large sources. Two shipments of spent fuel from the Turkey Point Nuclear Power Plant in Florida were inspected in transit near Atlanta by prearrangement on September 8, 1979. No significantly elevated exposure rates or surface contamination were found (see Table 2 and Appendix).

The final report for the year ending with this report is being prepared.

NUREG/CR-2033

Transportation of Radioactive Material in Georgia

October 1978 - September 1979

Prepared by *M. W. Carter, J. T. Gasper, B. Kahn

*Georgia Institute of Technology

Georgia Department of Human Resources

Prepared for
U.S. Nuclear Regulatory
Commission
and
U.S. Department of Transportation

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TRANSPORTATION OF RADIOACTIVE MATERIAL IN GEORGIA

October 1978 - September 1979

Prepared by

M. W. Carter
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B. Kahn

Manuscript Completed: March 1981
Date Published: May 1981

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Office of State Programs
U.S. Nuclear Regulatory Commission
Washington, DC 20555

and

U.S. Department of Transportation

NRC FIN B1639 and B1327

Abstract

Transportation of radioactive materials (RAM) in Georgia was studied for a second year, giving emphasis to surveying packages and vehicles, determining radiation exposure rates of workers, and enumerating and characterizing packages and vehicles. The survey of packages showed no significant radiation exposure or radionuclide contamination problems, but in a number of vehicles exposure rates exceeded 2 mR/hr at the driver's seat or 10 mR/hr at a distance of 6' from the surface. Of 81 workers who were issued dosimeters because they were considered to be the most highly exposed, one half did not show exposures above background, but 10 workers had exposures between 0.5 and 5 R per year above background. The number of RAM packages shipped per week, based on observations and reviews of records, consisted of approximately 300 radiopharmaceuticals plus a few for industrial, educational, and research purposes. Approximately 30 vehicles transported radiopharmaceuticals and 23 carried radioactive waste each week. Other RAM, including industrial materials, teletherapy sources, radiography sources, and fissionable materials were carried at much lesser frequency according to observations in this and the preceding year. On the basis of the observed occurrences of radiation exposures between 0.5 and 5 R/year to some workers, it is recommended that such workers be required to wear dosimeters so that elevated exposures may be detected and remedial measures can be undertaken.

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Acknowledgments

We wish to thank staff members of the Radiological Health Unit, Georgia Department of Human Resources, especially Mr. Willard Ingram, for their participation in this study. We also thank Mr. Donald Gibbons, Los Alamos Scientific Laboratory, for his advice, and the management and staff of the radioactive materials carriers for their cooperation in permitting access and providing information.

Transportation of Radioactive Material in Georgia

(Second Year of Study)

Introduction

Radioactive materials (RAM) are being transported in increasing numbers in the United States, especially for radiopharmaceutical use and in connection with the nuclear fuel cycle. The Department of Transportation and the Nuclear Regulatory Commission -- the Federal agencies responsible for controlling transportation of RAM under the regulations of 49 CFR Parts 171 - 178 and 10 CFR Part 71, respectively -- are jointly sponsoring a program of studies by state agencies and their contractors to examine RAM transportation (LA 78). These studies are evaluating the extent of compliance with regulations, the magnitude of radiation exposures to persons, and possible improvements in safety through changes in procedures or regulations. Most of these evaluations were performed at terminals of the airfreight carriers and freight forwarders that are major carriers of RAM (Mi 80, Pe 78, SC 38). In Illinois (Il 80), an innovative program of monitoring RAM transport on highways with detection instruments in patrol cars is being tested by the state police. This report presents the results obtained during the second year of a three-year study in Georgia.

The first year of study identified the major carriers of RAM and their terminals in Georgia, described the general pattern of RAM transport, and provided monitoring results (Ca 79). RAM transported in Georgia was classified as (1) radiopharmaceutical packages, (2) industrial, research and educational packages, (3) medical and industrial radiation sources, and (4) nuclear fuel cycle shipments. Radiopharmaceutical packages were the most numerous; approximately 15,000 per year were shipped through Atlanta, a major distribution center for the southeast. The number of packages in the second category was far smaller, but the total activity was approximately 10-fold the 10,000 curies (Ci) per year estimated for radiopharmaceuticals. Several teletherapy sources (mostly Co-60, 5,000 - 10,000 Ci each) and radiography sources (mostly Ir-192, approximately 100 Ci each) were shipped each year. Nuclear fuel cycle shipments included waste transported through Georgia to the Barnwell SC burial site, contaminated laundry, thorium mineral, and uranium hexafluoride. Spent fuel elements that contained several million curies of mixed fission products were shipped from reactors for experimental processing; these represented the largest amounts of radioactivity per shipment. Radiopharmaceutical and industrial/research/educational RAM were shipped by airplane or truck. All high-activity shipments, spent fuel and teletherapy sources in particular, were by truck. Thorium minerals and some uranium hexafluoride were transported by rail.

The report for the first year indicated minor infractions of regulations in labelling and packaging, although few of these resulted in obviously elevated personnel radiation exposures. Some procedures for dose reduction were suggested on the basis of periodic observations of RAM handling practices. Better delineation of radiation exposures and the amount of transported RAM was considered desirable, the former to determine whether some radiation exposures to transportation workers were excessive, and the latter, to evaluate the magnitude of any effort by the state to control RAM shipments more closely.

In response to these observations, the study during this second year emphasized measurement of radiation exposure to workers and determination of the magnitude of RAM shipments. Monitoring of packages and transport vehicles was continued to check compliance with package and label regulations and to measure external radiation and surface contamination levels. To measure personnel radiation exposure, thermoluminescent dosimeters (TLD's) were issued every 4 weeks for a year to approximately one hundred of potentially the most exposed drivers of vehicles and workers at terminals that handled RAM in Georgia. The numbers of RAM packages and shipments in Georgia were determined by observations and from shipment records at the Atlanta Hartsfield Airport, at the airfreight forwarder terminal near the Atlanta airport where most radiopharmaceutical packages are handled, and at the radioactive waste burial facility in Barnwell SC where such wastes are handled for the eastern United States.

Procedures

Surveys were undertaken and information was collected at the terminals of RAM airfreight carriers at the Atlanta Hartsfield Airport and at the terminal of the major RAM airfreight forwarder (air cargo service) and interstate carrier in Atlanta. In addition, information was collected at Barnwell SC from the operator of the radioactive waste surface repository and at the terminals of two interstate carriers. Some RAM trucks were surveyed in transit through Georgia. The carriers are listed in Appendix A. Information was obtained from staff at terminals, from drivers, and from records that include RAM logs, bills of lading, air bills, pilot notifications for restricted articles and burial records at the repository. Carriers of RAM were found among the large number of freight carriers through advice by Federal and State regulatory and radiation protection agencies, through inquiries at other carriers, and by tracing RAM shipments. The pattern of RAM shipments in Georgia had been delineated in the preceding year of the study (Ca 79).

Doses to drivers of trucks that carried RAM and to handlers at terminals where RAM were transferred were measured with TLD's. The TLD's were LiF chips, 0.12" x 0.12" x 0.035", placed in black plastic sleeves in sets of four. Exposure was determined with a Harshaw reader that had been calibrated in terms of milliroentgen (mR) with a Ra-226 standard. The

TLD's were issued by arrangement with supervisors to handlers and drivers for 4-week periods. Monitoring for a full year was attempted, but on numerous occasions the dosimeter could not be recovered or recovery was delayed by one or more 4-week periods. The workers were requested to carry the dosimeters in wallets, if possible, for the entire period, except that they were not to expose them to medical or dental radiation. This study was performed at the airfreight forwarder terminal (identification code D), two passenger airline cargo terminals (C and G) and two airfreight carrier terminals (A and I).

Two sets of confirmatory TLD's were also put in place at regular intervals, one at fixed locations in the terminals and the other in back of drivers' seats in trucks and vans that carried RAM. The vehicle TLD's were collected at 4-week intervals when possible and the terminal TLD's were collected at 3-month intervals. Some control TLD's were issued for persons and terminals to determine the natural background radiation exposure rates.

RAM packages and transport practices were surveyed at regular intervals throughout the year, generally during one week-end and on one day during midweek per 4-week period. The packages were examined for compliance with packaging, labelling and handling regulations and were surveyed for external radiation exposure rates and surface contamination. An ionization chamber survey meter (Jordan model AGB), calibrated with a Ra-226 standard source at 3-month intervals, was used for measuring radiation exposure rates. Smears of defined surface areas were analyzed by gross beta particle counting and gamma-ray spectral measurements. Trucks and vans at terminals were also examined for compliance with regulations and surveyed for external radiation exposure rates and surface contamination as they arrived or departed, or were unloaded or loaded. All of these activities were performed by arrangement with supervisors at terminals. Efforts were made to interfere as little as possible with the prompt transfer of RAM. Where observation indicated the potential for persons to receive elevated radiation exposure, supervisors or, if necessary, workers were cautioned and remedial practices were recommended.

Notification of intended shipment of spent nuclear fuel was provided by Georgia Department of Human Resources (DHR) staff, and scheduling information was telephoned by the shipper. Meetings for the purpose of the survey were arranged at truck stops near Atlanta with the truck line office. The trucks and shipping papers were examined for compliance with regulations. Georgia DHR staff was informed of all observations.

Georgia DHR and Department of Natural Resources (DNR) staff provided information concerning RAM incidents during shipment. These agencies were assisted in their response to incidents as part of this project. This assistance included participation in surveys and measurements of surface smears.

Information concerning the magnitude of RAM shipments through Georgia was compiled for radiopharmaceutical and industrial/research/educational packages transported through Atlanta by truck and airplane, and for radioactive waste transported by truck to the Barnwell burial site through Georgia. Records for weekly or monthly periods were compiled so that data could be compared. Data were collected in terms of numbers of packages, radioisotopes, curie amounts, transportation index (TI - highest number of mrem/hr at 3' from the surface of the package), and the labelling category (limited quantity, I, II, and III). Observations in the course of the surveys described above were used to confirm the records and obtain additional information.

Results and Discussion

Radiation Exposure to Workers

The summary of radiation exposure rates of workers who handled RAM at terminals or drove vehicles that carried RAM, given in Table 1 on the basis of the data in Appendix B-1, shows that one-half of the 81 workers had exposures that were not distinguishable from the natural radiation background. Average exposure rates for these workers were similar to averages for the three controls and were in the range of the background for external gamma rays plus cosmic rays of 6 to 14 uR/hr (1.0 to 2.4 mR/week) measured outdoors at Atlanta (Ka 79). The dosimeters were worn by these workers for 2 to 13 periods of approximately 4 weeks each, as shown in Appendix B-1. Data for 16 workers who wore their dosimeters for less than 2 periods because they left their job or did not cooperate in the study are not included in the tabulation.

With one exception, all workers at airline cargo terminals C and G and at airfreight terminals A and I (see Appendix B-1) were at background levels, although these were the workers at the 4 terminals most likely to be exposed to radiation. Low doses are attributed to relatively brief exposure to RAM, which are usually handled rapidly, remain at the terminals only for short periods, and are stored at a distance from locations where the workers spend most of their time.

All 10 workers in the highest-exposure category in Table 1 and 29 of the 30 workers that had some elevated exposures were issued TLD's at freight forwarder terminal D. As indicated in Appendix B-1, one of the workers (#56) in the highest category was a sorter while the others all were drivers on long-distance routes that carried relatively large amounts of radiopharmaceuticals, especially Mo-99 generators. These routes were:

Table 1

Summary of Worker Radiation Exposures

Category	No. of Persons	Total period, person-weeks	Range of exposure rates avg. mR/week	Range of exposure rates calc. mR/year
Controls	3	95	1.3- 1.6	68- 83
At background	41	1,297	0.9- 2.0	47- 100
<500 mrem/yr above background	30	1,001	2.1- 7.9	110- 410
>500 mrem/yr above background	10	199	12 -109	620-5,700

Notes:
1. Values are summary of data in Appendix B-1; values include natural background radiation exposure.
2. Controls were office workers at terminals.
3. Sixteen persons to whom dosimeters were issued are not included because exposure period for which dosimeters could be collected was less than 8 weeks.

#50 and 59:	carrier from New Brunswick NJ to Atlanta (continuing to Florida)
#51, 52, and 73:	carrier from St. Louis MO to Atlanta (continuing to Florida)
#18A:	freight forwarder from Memphis TN to Atlanta (RAM originated in St. Louis)
#3:	Atlanta freight forwarder, route to Montgomery AL
#9:	Atlanta freight forwarder, route to Orlando FL
#37:	Atlanta freight forwarder, route to Charlotte NC

The elevated doses to these drivers are believed to result from the combined effects of lengthy exposure in the driver's seat enroute and brief exposures at much higher rates during loading and unloading RAM. As an example, a 10-hour period of driving at the limit in a sole-use vehicle of 2 mR/hr would result in an exposure of 20 mR, and loading or unloading RAM of 2 TI at a typical surface exposure rate of 20 mR/hr per TI for 0.2 hour would add 8 mR. The local routes each generally carried RAM only once per week, hence doses computed by this procedure with appropriate times would apply to the entire week. Drivers for the interstate carriers from New Brunswick and St. Louis, however, may also have been exposed while transporting RAM on other routes.

Cooperation in the voluntary dosimetry program was remarkably good, but the exposure values in Appendix B-1 must be considered uncertain to some extent because not all dosimeters may have been worn throughout the exposure periods according to instructions. Two instances of unreliability are cited in the footnotes to Appendix B-1. In addition, uncertainty is caused by different exposure rates at parts of the body not monitored by the dosimeter and by exposures to various energies of gamma rays as well as energetic beta particles.

To check for major deviations in personnel dosimeter results from actual exposures, additional dosimeters were placed at the backs of drivers' seats in the vehicles that transported RAM and on walls and pillars in terminals where RAM were handled. Although these dosimeters could also have been manipulated to yield unduly high or low exposures, it was considered improbable that such results then be consistent with personnel dosimeter readings.

Of the 30 vehicles in which dosimeters were exposed for two to thirteen 4-week periods, Appendix B-2 indicates that five had average levels above 11 mR/week, six had levels similar to the natural radiation background (1.0 - 2.4 mR/week), and the remainder had intermediate levels indicating some contribution from RAM but not so much as to reach 500 mR/yr above background even at continuous occupancy. The routes of the vehicles that are known to have carried RAM are listed in Appendix B-3. The freight forwarder vehicles in Appendix B-2 had been selected by survey as those that carried highest TI values. The five highest exposures were in freight forwarder vehicles used on the following routes:

TLD	#21	Atlanta to Charlotte NC
	#26	Atlanta area
	#30	Atlanta to Montgomery AL
	#35	St. Louis MO to Atlanta and Orlando FL
	#61	Atlanta to Macon GA

Elevated exposures to drivers were found for the first and third of the above routes. The route with TLD #35 was transferred later in the year to an interstate carrier for which the drivers had elevated exposures. The Atlanta area route (TLD #26) transferred large amounts of RAM from the airport to the terminal over a short distance on Saturday evening. The driver on the route to Macon (TLD #46 at terminal D in Appendix B-1) was near the upper end of the intermediate exposure-rate range (7.8 mR/week). No dosimeters could be placed on the other vehicles known to carry high TI values: those of the carriers from New Brunswick and St. Louis.

The 27 dosimeters near RAM storage locations and the 13 dosimeters at control locations where no RAM were expected to be nearby showed the following distribution of average yearly exposure rates on the basis of 2 to 7 quarterly exposure measurements (see Appendix B-4):

13	controls	63 - 150 mR/yr
5	RAM locations at background	94 - 130
14	RAM locations 30-500 mR/yr above background	260 - 480
8	RAM locations more than 500 mR/yr above background	800 -3910

The range of exposure rates of 1.2 to 2.9 mR/week at control locations is above the generally observed outdoor natural radiation background and probably includes contributions from natural radiation in concrete walls and floors, and from RAM stored at a distance. As indicated in Appendix B-4, exposure rates of 290 and 360 mR/yr at two locations in terminal G were found to be due to a wall of concrete blocks that contain unusually high levels of radium-226 (Ka 79).

None of the dosimeters at airfreight terminals A, E, F, H, and I was in the highest exposure category, although some elevated radiation levels were observed. One of the highest exposure locations was at airline cargo terminal C due to shipments of Mo-99 generators from Squibb during the early part of the study. These were later shipped by truck, whereupon the exposure rate at the terminal decreased, as shown in Appendix B-4. At airline cargo terminal G, two locations showed some elevated radiation levels due to RAM, but neither was in the highest exposure category. All other locations in the highest exposure category were at freight forwarder terminal D, consistent with the movement of most radiopharmaceutical RAM through this terminal, as discussed below. These elevated doses were near collection points of RAM for distribution and near loading/unloading sites for RAM transport vehicles. In general, these RAM packages remained at the terminal for periods that ranged from minutes (direct transfer from

incoming to outgoing vehicle) to 1.5 days (unloaded Saturday afternoon and loaded Sunday night or early Monday morning). Infrequently, a RAM package remained for days or even weeks because shipping papers were lost.

In summary, personnel dosimeters had been issued to all workers who were believed to have the potential for measurably increased radiation exposure due to RAM. As indicated, however, several workers did not wear or return the dosimeters. In addition, the tabulation in Appendix B-1 shows that some workers for whom radiation exposure data are available did not return TLD's for every period. Hence, although the personnel exposure information is considered to be generally applicable to airline cargo, airfreight, and freight forwarder workers at Atlanta, and to the drivers of two interstate carriers of radiopharmaceuticals to Atlanta, it is not complete and may include some unreliable values.

The dosimeters placed in vehicles and at terminals, as well as the radiation surveys of vehicles listed in Appendix D, provide support for the observations that elevated exposures were received by some workers, but that most working conditions were at relatively low exposure rates. The radiation exposure values obtained for individual workers unfortunately in most instances could not be directly compared to these supporting measurements because work assignments and RAM shipments varied so greatly within measurement periods.

Survey of RAM Shipments

No occurrences with the potential for significant radiation exposures of persons were observed during the year in the course of surveying the 230 RAM packages listed in Appendix C. Deviations from usual shipping information reporting and infractions of shipping regulations are summarized in Table 2 in the form previously used by the US NRC (LA 78). In the 57 instances of measured TI above the value on the label, the measurement once exceeded the recorded value by 1.0; in all other instances, the difference was only 0.1. Occurrences of measured TI below the value on the label apply mostly to short-lived Mo-99, which decays rapidly and hence decreases in TI value during shipment. Consideration of this decay by the shipper is also believed responsible for the lesser curie amounts indicated on freight bills than on the label of Mo-99 generator packages.

The packages encountered most frequently in the survey contained Mo-99 in Tc-99m generators; second most common were I-131 solutions. In general, RAM packages remained very briefly at airline cargo and airfreight terminals because they were placed on outgoing airplanes or collected by the airfreight forwarder for truck transport within a few hours of arrival. RAM constituted a very small fraction of packages at all terminals. As indicated in the following section, these terminals handled only a few RAM packages per week.

Table 2

Summary of RAM Package Surveys*

	Item	Number of Occurrences
1	No label	0
2	Wrong label	4 (1)
3	TI observed <TI label	138
4	TI observed >TI label	57 (2)
5	Security seal broken	1
6	No or improper security seal	0
7	Package authority not listed or covered	1
8	Proper shipping name missing or unlisted	1
9	Surface dose rate >Yellow II limit	0
10	Surface dose rate >Yellow III limit	0
11	Nonspecification packages	0
12	Detectable or removable contamination	19
	Removable activity above DOT limits	0
13	TI not recorded	2
14	Special form material not labeled as special form	0
15	Greater than 50 TI in storage	12 (3)
16	Storage separation distances less than allowed	12 (3)
17	Label covered with air bill envelope	2

* Data were compiled from inspection of following packages:

Package Type			Category				Total Packages	Total TI
A	B	Overpack	Ltd	I	II	III		
223	5	2	16	5	66	143	230	305.4

Notes:
1. I-131 packages with recorded TI's of 0.4-0.7 (confirmed by monitoring) had Yellow III labels instead of Yellow II.
2. Four USA DOT 20 WCL Type B containers with Mo-99 read over recorded TI; however, since containers could not be moved, higher reading could be contribution from adjacent containers.
3. During each of the monthly weekend visits to one main terminal, the RAM unloaded from trucks were stacked in piles over 50 TI and not separated by 20 feet.

Occurrences that might cause elevated radiation exposures, such as storage of RAM with more than 50 TI near workers or photographic film, were reported to terminal management and in most cases promptly corrected. Other occurrences that were believed to be infractions of regulations were reported either at the time of observation or by copy of quarterly report.

The survey of RAM transport vehicles summarized in Table 3 from the tabulation in Appendix D found levels above 2.0 mR/hr in cabs on 33 occasions among 172 measurements for radiopharmaceutical shipments, and TI exceeding 50 on 48 occasions in trucks or vans. These vehicles also exceeded exposure rates of 10 mR/hr six feet from the surface on 8 occasions. Under current regulations, dose rates in sole-use vehicles are restricted to the indicated levels, while other vehicles are restricted to a maximum of 50 TI, with the RAM placed beyond specified minimum distances from the driver to maintain low exposures. Of 54 vehicles checked for proper display of placards on sides, front and back at time of departure, 11 were not in compliance but the driver in each case was notified and corrected the situation. Another 10 vehicles were found parked without proper placard display at the freight forwarder terminal, but it is not known whether placards were displayed in transit. Improper shipping documents were due to splitting loads between two vehicles with a single freight bill or the driver having interchanged freight bills by mistake.

Elevated radiation exposure rates were found repeatedly in surveys at driver's seats on the following routes:

St. Louis to Atlanta freight forwarder
New Brunswick to Atlanta interstate carrier
Atlanta to Charlotte freight forwarder
Atlanta area freight forwarder (two routes)
Atlanta to Orlando freight forwarder (continuation of St. Louis to Atlanta route)
Atlanta to Montgomery freight forwarder
Atlanta to Macon freight forwarder

The highest radiation levels were caused by carrying more than 50 TI and having insufficient separation distance between RAM packages and the driver.

All of the above-listed routes had average exposure rates above 11 mR/week at TLD's placed behind the driver's seat, according to Appendix B-2 (see preceding section). Average exposure rates over extended periods were lower in vans used for the Atlanta area routes because the RAM packages were carried only for brief periods. For example, packages with large TI values, that were picked up at Charlie Brown Airport in Atlanta where a small chartered airplane delivered RAM (see Appendix B-3), were unloaded at the freight forwarder terminal within approximately 20 minutes after loading.

Table 3

Summary of RAM Transport Vehicle Surveys

	Radiopharmaceutical	Nuclear Fuel Cycle
No. of vehicles	172	2
Radiation levels, mR/hr		
Cab average (max.)	1.7 (28)	0.05 (0.07)
Surface average (max.)	31.4 (120) for 153 veh.	3.1 (3.5)
6-ft distant avg. (max.)	4.4 (17) for 168 veh.	1.0 (1.2)
TI average (max.)	47 (350) for 168 veh.	6.0 (8.0)
Excessive removable contamination	No, 11 vehicles of 25 vehicles had contamination below allowable limits.	No, 1 load had contamination below allowable limits.
Excessive radiation levels at driver's seat	6 violations, all on the same route.	None
Excessive TI	11 violations, all on the same route.	None
Package placement	RAM generally in rear; 23 separation distance violations.	Not applicable
Proper shipping documents	Of 156 vehicles, 11 had improper shipping documents.	Yes
Placards	Yes for 54 vehicles, but 11 vehicles did not have all placards displayed.	Yes

Among the surveyed personnel, dosimeters issued by shippers or carriers were worn by the drivers of the three interstate carriers and the pilots of one airfreight carrier (identified in Appendix B-3 as AC, SK, NE, and BA). Radiation monitoring instruments were available at Terminal C.

Procedures to reduce the dose to drivers were recommended to supervisors at the Atlanta freight forwarder terminal and the interstate carriers from St. Louis and New Brunswick to Atlanta. These consist of greater separation distance between driver and RAM, lead shielding around RAM, reduction of TI per vehicle, and loading RAM to maximize distance from highest TI to the driver for reducing the dose in transit; and rapid unloading/loading techniques with assistance from handlers at terminals for reducing the dose while at origin and destinations. In two instances, (Atlanta to Macon and Atlanta to Montgomery routes) the freight forwarder responded positively by providing larger trucks to increase the separation distance, and for several other routes two vans were used subsequently in place of one.

One group of spent fuel shipments was scheduled in September-October 1979 from the Turkey Point (Florida) Nuclear Power Plant, with 5 truckloads to Ohio and 8 to Nevada. Nuclear power plant staff provided notification of the departure time for each truck. The second and third of the trucks were surveyed at a highway truck stop near Atlanta on September 8, 1979 at 3 a.m. and 9 a.m. and were found to be in compliance as indicated in Table 3. All shipments passed through Georgia. The first shipment had been surveyed by Florida state agency staff.

None of the RAM packages and transport vehicles checked during the year showed surface contamination above the limit of 100 pCi/cm^2. All of the surface smears that contained detectable radioactivity are listed in Table 4; as indicated, the highest levels were well below 1 pCi/cm^2. Although Mo-99 and I-131 were transported in greatest quantity, the radionuclide most commonly found on surfaces associated with radiopharmaceuticals transport was Se-75.

The following incidents with RAM transport occurred during the year:

1. On October 10, 1978, staff at a Chattanooga hospital measured an exposure rate of 30 - 50 mR/hr at 3' from a Squibb Mo-99 generator package (0.8 Ci, TI 1.6) delivered that day. Tennessee and Georgia state agency staffs were informed by the hospital. Absence of part of the lead shield may have been responsible for the elevated exposure rate. The TLD of the driver who had delivered the RAM (terminal D, Route 014) was collected and read on October 16. For the 2-month exposure period since dosimeter issuance on August 16, the exposure was 60 mR, approximately 46 mR above background. The average exposure rate for the driver during this year was 3.2 mR/week, or approximately 28 mR for the period, as shown in Appendix B-1. Hence, part of the elevated TLD reading may have been exposure from this Mo-99 generator.

TABLE 4

Surface Contamination Measured by Smears of Trucks and RAM

Date	Area, cm^2	Object smeared	Radionuclide level, $pCi/100cm^2$			
			Se-75	Mo-99	I-131	Other
10/14/78	3,700	61663 Ryder truck, rear of bed	0.5	<0.1	1.2	---
10/15/78	22,000	H-3 drum USA/6678/BL	---	---	---	0.2 H-3
11/18/78	20,000	SQ (3 Mo-99, 1 I-131)	0.3	<0.1	<0.1	---
11/18/78	4,300	61663 Ryder truck, rear of bed	5.8	<0.1	<0.1	---
11/18/78	1,100	steering wheel	0.3	<0.1	<0.1	---
12/16/78	3,700	61663 Ryder truck, rear of bed	1.8	<0.1	<0.1	---
12/19/78	5,500	SQ Mo-99	0.09	4.2	0.12	---
1/13/79	3,700	61663 Ryder truck, rear of bed	1.8	0.34	0.36	---
1/14/79	5,100	1 SQ Mo-99	<0.01	<0.05	81.0	---
1/14/79	10,600	1 MA Mo-99	<0.01	0.007	<0.02	---
2/10/79	3,700	61663 Ryder truck, rear of bed	0.97	0.13	0.070	---
2/11/79	4,700	Skycab van, steering wheel and rear bed	0.063	0.032	0.20	---
2/13/79	23,100	2 SQ Mo-99; 1 UC I-131; 1 NE I-125	0.014	0.039	0.022	---
3/11/79	26,200	1 NE Mo-99; 1 MA Mo-99; 2 NE P-32	0.012	0.005	<0.02	---
4/ 6/79	28,000	4 Medi Physics Mo-99 packages Type 'B'	0.064	0.047	0.005	---
4/ 7/79	14,800	12 MA I-131	0.13	0.049	0.057	---
4/ 7/79	186,000	18 MA Mo-99	0.19	0.13	<0.005	---

TABLE 4 (CONTINUED)

Surface Contamination Measured by Smears of Trucks and RAM

Date	Area, cm^2	Object smeared	Radionuclide level, $pCi/100cm^2$ Se-75	Mo-99	I-131	Other
5/ 5/79	103,000	10 MA Mo-99	0.02	0.12	0.01	---
6/ 2/79	1,300	Associated Courier tractor #71817 (steering wheel)*	66.	<0.05	<0.4	---
6/ 5/79	13,100	3 Medi Physics In-111, Ga-67 and I-123	<0.03	0.032	<0.02	---
6/30/79	12,000	20 MA Mo-99	0.16	<0.05	<0.03	---
7/ 1/79	2,100	Associated Courier trailer #P83090 (rear bed)	0.35	<0.2	<0.2	---
7/13/79	100	2 SQ Mo-99	<0.02	0.087	<0.02	---
7/28/79	12,000	9 MA I-131	0.02	<0.02	<0.02	---
7/28/79	14,000	9 MA Mo-99	0.06	<0.02	<0.02	---
7/28/79	5,000	Associated Courier vehicle steering wheel and rear of trailer bed	0.32	<0.02	<0.02	---
9/ 1/79	15,000	9 MA Mo-99,	0.02	0.11	<0.02	---
9/ 1/79	13,000	9 MA I-131	<0.02	<0.02	0.06	---
9/ 8/79	400	Spent Fuel NL Trailer #73372, Turkey Point to Ohio. Tri-State Transportation Co.	<1	-	<1	0.5 Co-57 5.3 Co-60 1.9 Cs-137
9/20/79	5,600	Skycab Veh. 532 KOG, rear of bed	<0.03	<0.02	0.075	---
9/29/79	8,300	5 MA Mo-99	0.12	0.11	-	---
9/29/79	20,000	4 SQ Mo-99	0.02	<0.02	<0.02	

TABLE 4 (CONTINUED)

Surface Contamination Measured by Smears of Trucks and RAM

Date	Area, cm^2	Object smeared	Radionuclide level, $pCi/100cm^2$			
			Se-75	Mo-99	I-131	Other
9/29/79	5,600	Associated Courier trailer, rear of bed	0.86	0.11	-	---

Notes: MA = Mallinckrodt
SQ = Squibb
NE = New England Nuclear
UC = Union Carbide

* Truck bed was not smeared.

2. On February 2, 1979, a flat-bed rail car that carried two trailers derailed at the Tilford Yard of the L & N (Family Lines) Railroad in Atlanta. The two trailers carried bags of monazite (a thorium ore that also contains high levels of uranium) from the port of Charleston SC to Chattanooga TN. The top of one trailer broke open and spilled monazite over the immediate area; the other trailer was deformed from the shifting load but retained the monazite. The 50-kg bags of monazite loaded on pallets in the trailers had yellow II labels; the trailers had yellow III labels showing natural thorium as RAM content, 0.126 Ci, TI 7. Exposure rates measured outside the trailers were as high as 13 mR/hr at the surfaces and 5 mR/hr at 3 feet. The unopened trailer and the unopened bags in the broken trailer were sent to their destination. Contaminated soil was collected in drums, sealed by a contractor for the railroad and stored in Atlanta, where it still remains. Only a small residue of monazite was on the ground according to the survey performed after decontamination.

3. On July 13, 1979, Georgia DNR staff surveyed two Squibb Mo-99 generator packages that had been refused by an Eastern Airline pilot at the Atlanta airport because package surfaces were wet. The RAM showed no elevated readings compared to the label, and the smear had only low levels of Mo-99 (see Table 4, entry for July 13, 1979).

4. On July 27, 1979, staff assisted NRC in searching the Eastern Airlines cargo terminal for a Mallinckrodt I-131 package sent from St. Louis MO to Charlotte NC but not received there. The package was not found.

5. On August 4, 1979, a package of Squibb Co-57 was crushed at the Eastern Airlines cargo terminal. Georgia DNR staff observed that the contents of the package -- 3 bottles and 4 vials -- remained unbroken. The vials were repacked. No smear was taken.

Extent of RAM Shipments in Georgia

The typical volume of radiopharmaceutical RAM handled at the airfreight forwarder Terminal D in Atlanta on a weekend was 274 packages in categories I, II, and III, as shown in Table 5. The magnitude of shipments was similar in the preceding year (Ca 79). The packages were from four producers in Massachussetts, Missouri, New York and Illinois. They arrived by small chartered airplane or by truck to the greatest extent; a few packages were shipped by commercial airlines. Four truck routes -- three operated by interstate carriers and one by the airfreight forwarder (see Appendix B-3) -- made one delivery each weekend. By far the largest fraction of transported radiopharmaceutical RAM arrived late Friday to Sunday evening and was forwarded on Sunday and Monday morning.

The RAM packages were delivered throughout Georgia and to locations in northern Florida, southeastern Tennessee, eastern Alabama and southwestern North Carolina by the scheduled routes listed in Appendix B-3. The larger TI values were carried by airfreight forwarder vans from the airport and on

Table 5

Summary of Radiopharmaceutical Shipments Delivered from Airfreight Forwarder Terminal at Atlanta on Weekends

Origin, Manufacturer	Destination, State	No. of weekends	Radionuclide, no./week			Activity, Ci/wk	T.I. per week	Category, no./week				Total, no./week
			I-131	Mo-99	Other			Ltd	I	II	III	
NE	AL	10	0.1	8.5	18.0	10.6	31.1	1.9	10.7	5.1	8.9	26.6
	FL	10	0	3.0	3.0	4.3	12.5	0.5	1.9	0.6	3.0	6.0
	GA	10	0	15.2	20.5	17.6	53.2	2.5	12.0	5.6	15.6	35.7
MA	NC	10	11.6	35.2	4.3	32.1	65.7	3.4	0.2	8.9	38.5	50.0
	FL	10	6.3	51.5	2.2	73.8	115	1.5	0.1	4.5	53.9	60.0
	GA	13	14.1	18.9	2.8	17.7	38.1	2.1	0	12.9	20.8	35.8
SQ	AL	12	4.2	16.7	2.2	26.5	41.9	0.6	0.1	3.0	18.9	22.9
	FL	12	0.6	13.1	1.1	15.8	29.5	0.4	0	1.0	13.4	14.8
	GA	12	3.9	15.6	2.2	23.8	35.5	0.9	0.7	6.4	13.8	21.8
	TN	12	2.6	7.7	1.6	12.4	13.2	1.0	0	1.3	9.5	11.8
AM	GA	1	0	0	3.0	0.006	0.2	1.0	1.0	1.0	0	3.0
	NC	1	0	0	9.0	0.005	0.1	8.0	0	1.0	0	9.0
	SC	1	0	0	1.0	---	---	1.0	0	0	0	1.0
TOTAL			43.4	185	71.1	235	436	25	27	51	196	298

Notes: 1. Shipments were monitored approximately every four weeks (AM was monitored on April 8, 1979).
2. Manufacturer code: NE-New England Nuclear, MA-Mallinckrodt, SQ-Squibb, AM-Amersham.
3. NE shipments to Florida were routed through Montgomery, AL to Pensacola and Panama City.

express routes. Occasional RAM packages were carried on local routes and on express routes midweek. Included in Table 5 are RAM on two interstate carrier trucks -- one to Charlotte NC and Orlando, FL and the other directly to Orlando FL (see Appendix B-3) -- that remained for shipping to these destinations after unloading the RAM for local distribution at Terminal D.

Of these packages, two-thirds were Mo-99 (Tc-99m generators), which accounted for almost all category III packages and most of the TI and curie amounts. The generators were usually 2 TI each. Iodine-131 was the second most numerous radioisotope. Others were I-123, Co-57, Ga-67, Yb-169, In-111, Cr-51, Tl-201, H-3, C-14, Xe-133, Se-75, and I-125. The indicated number of limited quantity packages underestimates the amount shipped because only a small fraction was so labelled. Other radioisotopes in limited quantities were recognized by shipper and contents shown on the label.

Some additional radiopharmaceutical RAM were shipped by commercial airline during the week and distributed by the freight forwarder through Terminal D. The total (not including limited quantity) radiopharmaceuticals carried into Atlanta on two airlines of the three that handled RAM routinely were 92 per month, as shown in the airline cargo section of Table 6. The number of packages terminating at airline C could not be determined, but was estimated to be the same as for airline G, i.e., 56 per month. Thus the total by airline cargo was approximately 148 per month, or 34 per week. Of these, approximately five-sixth were shipped during the middle of the week according to Appendices E-2 and E-4. By adding the mid-week delivery of approximately 28 packages per week to the week-end rate of 274 packages, the total number of radiopharmaceutical RAM is near 300.

A few radiopharmaceutical packages were transported by air from Atlanta after transfer from other airplanes, to the extent indicated by the outbound shipments for airlines C, G, and B and airfreight line J in Table 6. These amounted to approximately 20 packages per week in categories I, II and III; details concerning contents and destinations are given in Appendices E-1, E-3, E-5, and E-9.

Packages of RAM in categories I, II, and III for industrial/research/educational purposes transported by airfreight carriers E, F and H outbound from Atlanta averaged 3 per week, and terminating packages on airfreight carrier H averaged 1 per week (see Table 6). One or two additional RAM packages per week were probably transported by airfreight carrier A, which was surveyed but did not provide shipment records. As indicated in Appendices E-6, E-7, and E-8, the TI of these packages generally was small, while the activity ranged from microcuries to thousands of curies. The radioisotopes included Ir-192, Co-58, Co-60, H-3, U-238, U-235, Pu-243, Pu-244, I-125, Kr-85, Mn-54, and Cs-137. Iridium-192 was shipped in quantities of several thousand curies from Oak Ridge TN to manufacturers of

Table 6

Summary of Monthly RAM Shipments at Atlanta Hartsfield Airport

Carrier	Period, 1979	Destination	Activity, Ci/month	Radionuclide, No./month I-131	Mo-99	Other	TI per month	Category, No./month Ltd	I	II	III	Total per month
Airline Cargo												
C	1/18 - 4/17	outbound		1.7	10	15	32	2.7	5	8.3	12	28
G	6/1 - 6/30	terminating	44	3	50	5	55	2	3	0	53	58
G	8/1 - 8/31	outbound	40	1	20	10	54	7	1	1	22	45
B	6/1 - 6/30	terminating	0.6	7	0	2	5.4	1	0	5	3	37
B	6/1 - 6/30	outbound	0.002	0	0	2	-	1	1	0	0	2
TOTAL			85	12.7	80	34	146	13.7	10	14.3	90	170
Airfreight												
E	4/1 - 8/31	outbound	3,000	0	0	2.4	1.5	0.2	0.4	1.4	0.4	2.4
F	6/1 - 6/30	outbound	53,000	0	0	11	1.1	4	5	2	0	11
H	6/1 - 7/31	terminating	0.05	0	0	4.5	0.8	0	0	4.5	0	4.5
H	6/1 - 7/31	outbound	0.31	0	0	6.5	1.4	1	0	5.5	0	6.5
J	6/1 - 8/31	outbound	-	-	-	-	18.8	-	-	-	-	25
TOTAL			56,000	0	0	24	24	5.2	5.4	13.4	0.4	49

Notes: 1. Data were obtained from airbills, restricted articles forms, hazardous material pilot notification forms, and hazardous material files.
2. At B Airline, data were not available for 11 of 18 shipments outbound for Activity, TI, and category, hence only 8 of 39 packages could be categorized.

radiography sources. Transport of these radiography sources by airfreight was observed on several occasions during the preceding year (Ca 79).

The origins of the airfreight outbound shipments in Appendices E-6, E-7, and E-8, indicate that 2-3 shipments per week of industrial/research/educational RAM were brought by truck to the Atlanta airport. These radionuclides originated at nearby sites such as Oak Ridge TN or the Georgia Institute of Technology reactor or were return shipments.

On the basis of data for 4 months summarized in Table 7 and given in detail in Appendices F-1 and F-2, RAM shipments by truck from or through Georgia to the radioactive waste burial site near Barnwell SC averaged 19 per week from nuclear power stations and 4 per week from other facilities. Six of the nuclear power plants and many of the other facilities are in Georgia, Alabama, and Florida and would be expected to use Georgia roads. Others are in the midwest and sent radioactive waste to Barnwell only because all other radioactive waste repositories east of the Mississippi River had been closed during the past several years. Shipments from the midwest usually were routed on Interstate Highways 75, 285, and 20 through Georgia to South Carolina. The radioactive wastes carried on special vehicles from nuclear power plants averaged 17 curies of mixed fission products per shipment; wastes from other facilities were usually less than 1 curie, except for the two sealed Cs-137 sources indicated in Table 7.

Other shipments of radioactive material included 13 truckloads of spent nuclear fuel (see preceding section). Each of the two monitored vehicles carried 800,000 Ci at TI's of 4 and 8. Shipments of teletherapy sources by truck, radiography sources by airplane and ores for producing nuclear fuel by railroad were not observed during the year but were reported in the preceding year (Ca 79).

Conclusion and Recommendations

A voluntary program of personnel dosimetry for what were considered to be the most exposed drivers of vehicles and workers at terminals showed that most of these persons working with or in the vicinity of RAM were exposed by RAM to less than 500 mR per year. In fact, approximately one-half of the persons had annual radiation exposures not measurably above the natural radiation background. Ten of the group, however showed exposure rates ranging from approximately 540 to 5,600 mR per year above background. Measurements of the radiation exposures at drivers' seats in these vehicles and at RAM storage locations in terminals confirmed that elevated radiation levels were associated with the above-cited exposures to individuals. The annual values of the exposures and the distribution of the values among workers must be considered approximate, however, because not all workers may have worn the dosimeters appropriately, and not all measurements could be performed for the full year.

Table 7

Summary of RAM Waste Shipments by Truck through Georgia to Barnwell, SC, During May 1-August 31, 1979

Origin	No. of shippers	No. of states	No. of carriers	No. of shipments	Activity, Ci
Nuclear power stations	14	9	5	321	5,400
Other facilities	39	14	21	66	35
	1			2	86,000

Notes: 1. Information is summarized from Appendices F-1 and F-2.
2. Two shipments listed separately under "Other facilities" consisted of two sealed 43,000 Ci Cs-137 sources.

Exposure rates at levels significantly above background result mainly from shipments of Mo-99 (Tc-99m generators), which typically have radiation exposure levels near 20 mR/hr at the surface. In transporting numerous packages of these generators, loading and unloading them, and storing them for transfer, some radiation exposure to workers is inevitable. Good practices in maintaining recommended distances between RAM packages and workers and handling the packages as briefly as possible were found to keep exposures to a minimum. Not all workers were uniformly well trained in handling RAM, however, and the relatively rapid turnover of workers makes consistent and sufficient training difficult. It is recommended that workers with RAM that have the potential for measurable exposures from RAM be required to wear dosimeters so that instances of elevated radiation exposures be identified for remedial action.

The monitored packages of RAM were, on the whole, shipped in accordance with regulations and did not cause undue radiation levels or radionuclide contamination. The most prevalent surface contaminant among radiopharmaceuticals, although at levels far below the limits, was Se-75. Trucks and vans that transported RAM in several instances did not have proper shipping documents or display placards as required. The most serious problem was considered to be consistently elevated radiation doses to drivers for several routes that carried numerous Mo-99 packages, some in sole use vehicles. It is recommended that drivers on these routes be considered radiation workers and be subject to associated requirements, especially wearing dosimeters and training in pertinent radiation protection and dose reduction procedures.

The questions raised in the preceding report regarding overpacks and sole use vehicles still remain. In an overpack, the TI value of the combined RAM packages is reduced to a fraction of the sum of TI values; it is not clear whether this result is in accord with the regulatory intent. A dose rate to the driver in a sole use vehicle at the limit of 2 mrem per hour (49 CFR Part 173.393 (j) may expose the driver to levels well above 500 mrem per year. Similar or higher dose rates apparently also can occur in non-sole use vehicles under the minimum separation distances specified in 49 CFR Part 177.842 (b).

Two accidents that involved RAM shipments occurred during the year, of which one was minor and neither resulted in serious radionuclide contamination or radiation exposure. Needed for accident response at this time are clear instructions concerning whom to notify and what to do until the appropriate radiation protection personnel arrive.

The weekly number of RAM packages shipped in Georgia was estimated to be 300 radiopharmaceuticals and 5-6 for industrial/research/education use. Approximately 35 trucks and vans carry these packages through Georgia each week. The major contributor to the TI value (i.e., the dose rate) is Mo-99. In addition, 23 trucks per week on the average carried radioactive

waste through Georgia to the radioactive waste burial site at Barnwell SC. One group of spent fuel elements was shipped by truck from a nuclear power station during the year, and some shipments of teletherapy sources by truck, movement of radiography sources in vans, and transport of radioactive ores by rail usually occur, as reported for the preceding year. More definitive data are expected to be available next year when reporting and registration will be required under the Transportation of Hazardous Materials Act (Georgia Act No. 487) and the corresponding State Department of Transportation Rules (Chapter 672-10). These apply to carriers that operate exclusive use vehicles or carry spent fuels, RAM with TI in excess of 50, and "large quantities" of radionuclides as defined in 49 CFR Part 173.389(b).

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*Available for purchase from the NRC/GPO Sales Program, U.S. Nuclear Regulatory Commission, Washington, DC 20555, and/or the National Technical Information Service, Springfield, VA 22161.

**Available for purchase from the National Technical Information Service.

Appendix A

RAM Carriers in Georgia Contacted in Study

Airlines

Passenger:
- Delta Airlines
- Eastern Airlines
- Piedmont Airlines
- Republic Airlines
- United Airlines

Air Cargo Service:
- Airborne Freight
- Airlift International
- Burlington Northern Air Freight
- Emery
- Federal Express
- Flying Tiger
- Kenworthy Air Freight
- Midwest
- Personalized Agent Service, Inc
- Profit by Air

Air Cargo Service and Interstate Carrier:
- Purolator

Truck Lines

Interstate Carrier:
- Associated Courier
- Branch Motor Express*
- Chem-Nuclear Systems, Inc
- Hacke Transportation*
- Hittman Transport Services, Inc*
- Home Transportation Co
- Mason & Dixon Lines, Inc*
- McCormack Highway Transportation, Inc*
- McLean Trucking Co*
- New England Nuclear
- Overnight Transportation Co*
- Roadway Express Co*
- Skycab
- Spartan Express*
- Superior Trucking Co*
- Tri-State Motor Transit Co
- Yellow Freight System*

* contacted by telephone only

Appendix B-1

Personnel Radiation Exposure of Drivers and Workers at Transport Terminals

Person I.D. No.	11/15/78 to 12/15/78	12/15/78 to 1/11/79	1/11/79 to 2/8/79	2/8/79 to 3/8/79	3/8/79 to 4/5/79	4/5/79 to 5/3/79	5/3/79 to 5/31/79	5/31/79 to 6/28/79	6/28/79 to 7/26/79	7/26/79 to 8/30/79	8/30/79 to 9/27/79	9/27/79 to 10/25/79	10/25/79 to 12/13/79	Exposure, mR (includes natural radiation background) Total (No of weeks)	Average per week
Terminal A															
1	6.7	4.8	4.7	--	--	--	--	--	--	--	--	--	--	16.2 (12)	1.4
1A	--	--	--	--	--	7.2	8.0	8.8	(1)	13 (1)	NR*	4.1	9.2	50.3 (27)	1.9
2	5.0	4.2	6.2	5.6	6.3	6.7	6.5	--	--	--	--	--	--	40.5 (28)	1.5
3	(1)	10.1 (1)	5.0	--	--	--	--	--	--	--	--	--	--	15.1 (8)	1.9
4	(1)	10.7 (1)	NR	NR	--	--	--	--	--	--	--	--	--	24.2 (15)	1.6
Terminal C															
1 (C)+	--	5.6	5.7	5.0	NR	6.5	(1)	12 (1)	5.6	6.7	4.5	3.5	--	55.1 (44)	1.3
2	--	NR	7.0	5.0	6.7	7.9	6.3	6.5	4.6	NR	--	--	--	44 (28)	1.6
3	4.4	5.4	6.0	5.0	6.8	6.2	6.5	7.0	5.4	6.1	4.6	3.8	9.7	76.9 (55)	1.4
4	7.7	8.2	5.5	5.5	6.0	6.5	6.3	6.5	4.6	NR	NR	NR	--	56.8 (36)	1.6
5	5.1	3.9	5.2	5.0	NR	5.5	6.6	NR	(1)	8.9 (1)	4.4	3.4	--	48 (44)	1.1
6A	--	--	--	--	--	4.7	6.1	(1)	9.0 (1)	6.6	5.2	3.3	7.2	42.1 (35)	1.2
7	--	5.0	5.6	(1)	14 (1)	4.6	7.8	6.5	4.9	5.7	7.8	4.2	9.8	75.9 (51)	1.2
8	--	4.7	5.5	(1)	11 (1)	5.3	6.0	6.2	4.0	(1)	(1)	(1)	6.7	62.4 (51)	1.5
9	--	4.2	5.0	(1)	(1)	(1)	21.0 (1)	--	--	--	3.9	3.5	--	37.6 (32)	1.2
9A	--	--	--	--	--	6.0	6.1	4.2	4.2	5.2	4.5	3.4	12.1	45.7 (35)	1.3
10	5.7	6.0	(1)	(1)	(1)	19 (1)	5.4	3.6	NR	5.0	3.9	3.5	6.1	58.2 (51)	1.1
11	6.3	5.3	5.2	--	--	(1)	14 (1)	5.2	4.6	(1)	(1)	(1)	22 (1)	63 (48)	1.3
12A	--	--	NR	NR	--	5.5	5.2	4.4	4.7	4.4	4.6	3.9	6.9	39.6 (35)	1.1
13	6.0	5.9	5.0	--	--	--	5.4	4.7	(1)	9.8 (1)	4.5	3.6	7.1	52 (43)	1.2
15	--	--	--	--	--	9.2	NR	6.2	NR	--	--	--	--	15.4 (8)	1.9
16	6.7	(1)	(1)	(1)	(1)	27 (1)	6.8	7.2	5.3	6.0	6.7	4.6	9.1	79.4 (55)	1.4
17	--	--	--	--	--	--	--	5.7	5.0	4.4	5.3	4.3	8.2	32.9 (27)	1.2
18	--	--	--	--	--	--	--	--	--	--	--	2.9	7.6	10.5 (11)	1.0
7A	--	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	40 (1)	--	40 (45)	0.9
Terminal D															
1(C)	8.0	4.5	8.3	5.0	9.3	11	NR	--	--	6.0	5.7	4.2	7.7	69.7 (43)	1.6
1A(C)	--	--	--	--	--	--	--	7.3	4.8	--	--	--	--	12.1 (8)	1.5
2	16	8.6	20	12	21	18	17	(1)	21 (1)	12	7.8	--	--	153.4 (44)	3.5
3	150	130	130	44	30	35	28	23	25	29	13	8.2	NR	645 (48)	13.4
4	11.4	8.3	11	5.0	13	7.0	6.5	7.2	(1)	16 (1)	12.0	29	45.0	171.6 (55)	3.1
5A	--	NR	12	NR	12	16	12	9.8	NR	NR	NR	10	--	71.2 (24)	3.0
6	14	9.0	8.0	10	12	18	20	15	11	15	11	11	--	154 (48)	3.2
7	38	40	49	33	40	18	36	30	39	47	16	23	24	433 (55)	7.9
8	16	5.5	(1)	9.4 (1)	6.8	5.8	9.6	5.7	NR	--	--	--	--	58.8 (32)	1.8
9	80	48	84	13	14	NR	--	--	--	--	--	--	--	239 (20)	12
10	--	(1)	22 (1)	37	NR	NR	--	--	--	--	--	--	--	59 (12)	4.9
11	17	10.7	18	9.0	16	17	33	18	27	27	11	16	13.4	233 (55)	4.2
12	17	31	37	46	18	32	41	17	42	18	29	34	68	430 (55)	7.8
13	14	10	14	15	20	(1)	23 (1)	NR	--	--	--	--	--	96 (28)	3.4
14	19	11	19	20	(1)	16 (1)	6.5	(1)	10 (1)	6.7	(1)	9.0 (1)	7.7	124.9 (55)	2.3
15	10.6	7.6	NR	20	10	NR	NR	21	11	8.0	9.2	NR	--	97.4 (32)	3.0
16	NR	5.9	8.0	NR	12	15	16	14	7.1	NR	--	NR	--	78 (28)	2.8
17	--	NR	7.0	NR	8.0	18	9.0	NR	9.3	(1)	17 (1)	NR	--	68.3 (28)	2.4

Appendix B-1 (Cont'd.)

Person I.D. No.	11/15/78 to 12/15/78	12/15/78 to 1/11/79	1/11/79 to 2/8/79	2/8/79 to 3/8/79	3/8/79 to 4/5/79	4/5/79 to 5/3/79	5/3/79 to 5/31/79	5/31/79 to 6/28/79	6/28/79 to 7/26/79	7/26/79 to 8/30/79	8/30/79 to 9/27/79	9/27/79 to 10/25/79	10/25/79 to 12/13/79	Exposure, mR (includes natural radiation background) Total (No of weeks)		Average per week
18	5.1	3.5	--	--	--	--	--	--	--	--	--	--	--	8.6	(8)	1.1
18A	(1)	190 (1)	150	NR	--	--	--	--	--	--	--	--	--	340	(12)	28
18B	--	--	--	--	--	8.4	10	9.9	6.3	8.9	(1)	14 (1)	10.4	67.9	(35)	1.9
19A	--	--	--	17.8	6.0	11	11	NR	--	6.8	15	5.2	--	72.8	(28)	2.6
31	NR	15	28	39	27	NR	20	27	8.2	NR	--	--	--	164.2	(28)	5.9
36	--	--	(1)	25 (1)	NR	--	--	--	--	--	--	--	--	25	(8)	3.1
36A	--	--	--	--	(1)	18 (1)	8.6	(1)	14 (1)	13	6.2	6.3	--	66.1	(32)	2.1
37	--	30	88	49	NR	NR	--	--	--	--	--	--	--	167	(12)	13.9
39	--	6.8	8.0	10	9.5	7.2	9.2	(1)	11 (1)	7.9	8.3	15	--	92.9	(44)	2.1
42	--	--	7.3	6.0	16	20	14	16	20	--	--	--	--	99.3	(28)	3.5
43	--	--	27	7.0	25	12	12	12	(1)	(1)	33 (1)	11	12.1	151.1	(47)	3.2
45	--	--	17	17	17	18	17	(1)	27 (1)	21	21	18	28	201	(47)	4.3
46	--	--	--	34	46	38	47	(1)	37 (1)	(1)	46 (1)	30	57	335	(43)	7.8
47A	--	--	--	--	--	8.8	8.7	9.7	8.2	7.2	7.6	5.2	12.4	67.8	(35)	1.9
48	--	--	--	8.0	7.5	9.3	9.2	(1)	9.5 (1)	6.3	6.8	(1)	9.7 (1)	66.3	(43)	1.6
49	--	--	--	7.3	10	13	12	11	9.7	10.5	10.3	9.3	14.3	107.4	(43)	2.5
50	--	--	--	NR	NR	(1)	630 (1,2)	(1)	360 (1,2)	NR	NR	NR	--	990	(16)	62
51	--	--	--	--	(1)	400 (1)	150	NR	--	--	--	--	--	550	(12)	46
52	--	--	--	--	--	--	(1)	258 (1)	134	(1)	270 (1)	120	--	782	(24)	32
53	--	--	--	--	13	(1)	27 (1)	9.5	7.6	NR	NR	--	--	57.1	(20)	2.9
56	--	--	--	--	57	NR	63	79	33	60	NR	--	--	292	(20)	14.6
58	--	--	--	--	--	--	24	16	NR	--	--	--	--	40	(8)	5.0
59	--	--	--	--	--	--	400	NR	--	280	(1)	(1)	1390 (1)	2070	(19)	109
63	--	--	--	--	--	--	8.7	11	7.6	7.0	7.4	5.5	9.5	56.7	(29)	2.0
67	--	--	--	--	--	--	--	12	14	12	13	(1)	27.5 (1)	77.9	(27)	2.9
68	--	--	--	--	--	--	--	9.5	7.8	7.4	7.7	6.7	9.6	48.7	(27)	1.8
70	--	--	--	--	--	--	--	27	17	NR	17	14	21	96.4	(23)	4.2
73	--	--	--	--	--	--	--	--	100	(1)	270 (1)	113	--	483	(16)	30
74	--	--	--	--	--	--	--	--	21	21	17	14	NR	73	(16)	4.6
76	--	--	--	--	--	--	--	--	9.2	8.4	6.9	5.9	10.1	40.5	(23)	1.8
77	--	--	--	--	--	--	--	--	7.0	8.0	6.4	5.7	8.8	35.9	(23)	1.6
78	--	--	--	--	--	--	--	--	--	14	12	15	NR	41	(13)	3.2
82	--	--	--	--	--	--	--	--	--	--	5.7	7.3	--	13	(8)	1.6
83	--	--	--	--	--	--	--	--	--	--	--	6.1	9.7	15.8	(11)	1.4
84	--	--	--	--	--	--	--	--	--	--	--	8.1	10.1	18.2	(11)	1.7
Terminal G																
1	6.2	4.9	5.0	6.0	6.7	8.7	6.2	8.5	5.5	6.5	5.8	4.6	8.2	82.8	(55)	1.5
2	5.7	4.4	3.5	5.0	5.2	5.7	7.4	(1)	8.9 (1)	5.6	(1)	8.3 (1)	7.3	67	(51)	1.3
3	5.8	5.4	5.5	5.0	6.3	5.9	7.2	(1)	11.5 (1)	4.7	4.1	4.6	7.1	73.1	(51)	1.4
4	7.1	6.9	6.9	6.0	7.4	6.6	6.0	(1)	11.2 (1)	NR	5.2	4.8	10.2	78.3	(47)	1.7
5	--	--	--	--	--	--	--	--	--	NR	34	36	9.3	79.3	(12)	6.6 (3)
6	--	--	--	--	--	--	--	--	--	(1)	(1)	(1)	22 (1)	22	(19)	1.2
8	--	--	--	--	--	--	--	--	--	--	4.1	5.2	NR	9.3	(8)	1.2
Terminal I																
1	--	--	--	--	--	--	--	--	--	(1)	8.1 (1)	3.8	9.1	21	(17)	1.2

Appendix B-1 (Cont'd.)

Person I.D No.	
Terminal A	
1	CSA at counter
1A	Night Ramp Agent
2	Cargo Handler
3	Night Supervisor
4	Driver (picks up RAM)
Terminal C	
1(C)+	(B) Clerk (office on 2nd floor)
2	(C) SCSA Special Service Agent
3	(C) CSA Add-to/Spec Ser and inbound
4	(C) SCSA Delivery
5	(C) SCSA inbound
6A	(A) SCSA Spec Ser Agent
7	(A) CSA add-to
8	(A) CSA Sorter
9	(A) CSA Spec Ser Agent
9A	(A) SCSA Spec Ser Agent
10	(D) SCSA floor
11	(D) SCSA Spec Ser Agent
12A	(D) SCSA Add-to/outbound
13	(D) SCSA Sorting Area
15	(C) CSA
16	(C) Spec Ser Agent
17	(C) Spec Ser Agent
18	(A) SCSA Spec Ser Agent
7A	(A) CSA (Add-to Section)
Terminal D	
1(C)	Receptionist
1A(C)	Office Secretary
2	Driver, Rt 028
3	Driver, Rt 028
4	Driver, Rt 039
5A	Driver, Rt 015
6	Driver, Rt 014
7	Weekend Dispatcher
8	Driver, Rt 018
9	Driver, Atlanta to Orlando, FL
10	Driver, Rt 086
11	Driver, Rts 037, 086
12	Courier Terminal Sorter
13	Courier Terminal Sorter
14	Supervisor
15	Courier Terminal Sorter
16	Courier Terminal Sorter
17	Courier Terminal Sorter
18	Courier Terminal Van Loader
18A	Driver, Memphis, TN to Atlanta
18B	Driver Rt 002
19A	Driver, Rt 305
31	Driver, Rts 081, 036
36	Driver, Rt 080
36A	Driver/Supervisor, Rt 080
37	Driver, Rt 018
39	Driver, Rt 035
42	Supervisor
43	Driver, Rt 008
45	Driver, Rt 100
46	Driver, Rt 400
47A	Driver, Rt 045
48	Driver, Rt 001
49	Driver, Rts 016, 004
50	Driver, SK
51	Driver, AC
52	Co-driver, AC
53	Driver, Rt 103
56	Sorter
58	Sorter
59	Driver/Assistant, SK
63	Driver, Rt 011
67	Driver, Rt 024
68	Driver, Rt 051
70	Sorter
73	Co-driver, AC
74	Driver, Rt 080
76	Driver, Rt 005
77	Driver, Rt 006
78	Dispatcher (Sat)
82	Supervisor (Week nights)
83	Supervisor (Week nights)
84	Sorter (Mon-Sat)
Terminal G	
1	Ramp service (0800-1630 hrs)
2	Ramp service (1620-0020 hrs)
3	Ramp service (0010-0810 hrs)
4	Supervisor (0800-1700 hrs)
5	Ramp service (1620-0020)
6	Ramp service (0900-1730)
8	Ramp service (0110-0910)
Terminal I	
1	Driver (Atlanta)

NOTES FOR APPENDIX B-1

(1) TLD was worn for more than 1 period.

(2) Readings do not reflect true exposure to driver because TLDs were carried in the van instead of being worn on his person. Also, company-issued dosimeters were noted clipped to vehicle's sun-visor.

(3) Readings do not reflect true exposure to individual because of careless use of TLDs. The first TLD was lost. The other TLD with a reading of 36 mR was reviewed 3 days after being issued to the individual at terminal D, which picks up RAM from Terminal G.

(4) (C) = control

* NR: not recovered.

\+ Terminal C shifts: (A) 2315 - 0700 (B) 0800 - 1700
(C) 1500 - 2330 (D) 0700 - 1515

Appendix B-2

Radiation Exposure at Driver's Seat in RAM Transport Vehicle

Exposure, mR (includes natural radiation background)

TLD #	Vehicle #	Route ID	Nov.15 1978 to Dec.15 1978	Dec. 15 1978 to Jan. 11 1979	Jan. 11 1979 to Feb. 8 1979	Feb. 8 1979 to Mar. 8 1979	Mar. 8 1979 to Apr. 5 1979	Apr. 5 1979 to May 3 1979	May 3 1979 to May 31 1979	May 31 1979 to June 28 1979	June 28 1979 to July 26 1979	July 26 1979 to Aug. 30 1979	Aug. 30 1979 to Sept. 27 1979	Sept. 27 1979 to Oct. 25 1979	Oct. 25 1979 to Dec. 13 1979	Total/ weeks	Average per week
5	162024	FE	6	5	4	NR	---	---	---	---	---	---	---	---	---	15/12	1.3
20	15180	(015)	---	10	(1)	31 (1)	(1)	27 (1)	25	42	(1)	40 (1)	14	8	---	197/44	4.5
21	15195	(018)	---	NR	(1)	790 (1)	230	11	13	(1)	16 (1)	NR	(3)	---	---	1060/32	33
22	15181	(028)	61	14	18	45	29	43	24	(1)	(1)	(1)	(1)	109 (1)	19	362/55	6.6
23	15170	(039)	8	6	13	71	11	15	12	15	9	10	8	6	11	195/55	3.6
24	15171	(015)	---	17	6	9	9	12	NR	NR	---	---	---	---	---	53/20	2.7
25	15147	(a)	---	(1)	31 (1)	(1)	(1)	34 (1)	11	19	9	---	---	---	---	104/32	3.3
26	15201	(086,039)	190	17	(1)	21 (1)	38	8	49	8	(1)	21 (1)	10	(1)	22 (1)	384/56	6.8
26	15201 (2)	(086,039)	94	16	NR	---	---	---	---	---	---	---	---	---	---	110/8	13.7
27	15207	(014)	---	15	5	8	8	15	10	14	9	8	7	NR	9	108/47	2.3
28	15194	(305)	310	6	7	8	8	7	8	(1)	(1)	16 (1)	6	---	---	376/44	8.5
29A	15182	(086)	---	---	---	38	8	8	10	8	6	7	7	7	---	99/36	2.8
30	16144	(028)	16	24	105	(1)	(1)	(1)	190 (1)	24	34	64	38	---	---	495/44	11.3
33	37064	(018)	34	48	67	(1)	67 (1)	14	7	8	6	(1)	(1)	15 (1)	---	266/48	5.5
34	15165	(024,037, 080,039)	82	17	26	13	23	24	14	18	15	15	13	9	5	274/55	5.0
35A	15174	(081)	---	---	---	---	---	9	9	7	9	NR	9	7	9	59/31	1.9
35	61663	RT	420	450	420	NR	---	---	---	---	---	---	---	---	---	1290/12	108
38	16111	(a)	38	(1)	31 (1)	15	21	NR	---	---	---	---	---	---	---	105/20	5.3
40	15149	(035)	---	---	8	9	17	9	12	9	6	10	11	6	---	97/36	2.7
44	15145	(008)	---	---	(1)	(1)	(1)	(1)	(1)	(1)	(1)	120 (1)	13	8	45	186/47	4.0
54	15203	(080)	---	---	---	---	11	(1)	72 (1)	11	8	10	8	6	11	137/39	3.5
57	15208	(100)	---	---	---	---	27	NR	95	(1)	(1)	(1)	(1)	28 (1,4)	---	150/28	5.4
61	16725	(400)	---	---	---	---	---	---	150	28	11	NR	---	---	---	189/12	15.8
62	15205	(008)	---	---	---	---	---	---	16	22	NR	NR	---	---	---	38/8	4.8
64	15178	(011)	---	---	---	---	---	---	13	11	9	(1)	15 (1)	7	---	55/24	2.3
65	912	(039)	---	---	---	---	---	---	9	10	6	7	11	7	9	59/31	1.9
66	15209	(081)	---	---	---	---	---	---	---	48	17	11	12	6	30	124/27	4.6
69	15186	(051)	---	---	---	---	---	---	---	22	20	22	16	12	20	112/27	4.2
72	15192	(081)	---	---	---	---	---	---	---	---	15	12	17	14	20	51/23	2.2
85	15214	(028)	---	---	---	---	---	---	---	---	---	---	---	14	23	37/11	3.4

Notes:

NR not recovered

(1) for 2 or more periods, as indicated

(2) This TLD was positioned underneath right side of driver's seat in addition to TLD attached to rear of driver's seat.

(3) Vehicle 15195 destroyed in accident.

(4) Vehicle 15208 was sold approximately 3 months earlier, but TLD was returned by mail.

Appendix B-3

Routes of RAM Carriers in Georgia

Code Airfreight forwarder	Route
001	Atlanta to Cartersville/Chatsworth/Dalton, GA
002	Atlanta to Ducktown, TN
004	Atlanta to Toccoa, GA
005	Atlanta to Elberton, GA
006	Atlanta to Milledgeville, GA
008	Atlanta to Columbus, GA
011	Atlanta to Austell, GA
014	Atlanta to Chattanooga, TN
015	Atlanta to Chattanooga, TN (Express)
016	Atlanta to Gainesville, GA
018	Atlanta to Charlotte, NC (Express - to March 1979)
024	Atlanta Area
028	Atlanta to Montgomery, AL (Express)
035	Atlanta Airport; weekdays
037	Atlanta Area
039	Atlanta to Macon, GA
045	Atlanta to Hartwell, GA
051	Atlanta to Pine Mountain, GA
080	Atlanta Area Hospitals
081	Atlanta Area
086	Atlanta Area
091	Atlanta Area and Airport
100	Atlanta to Augusta, GA
103	Atlanta to Ft Gordon, GA
108	Atlanta to Ft Gordon, GA
305	Atlanta to Macon, GA (Express)
400	Atlanta to Macon, GA (Express)
(a)	Atlanta to Birmingham, AL (Express)
Ryder truck (RT)	St. Louis, MO - Memphis, TN - Birmingham, AL - Atlanta, GA - Orlando, FL (to January 1979) then RAM carried by AC, see below.
Interstate carriers	
AC	St Louis, MO - Memphis, TN - Birmingham, AL - Atlanta, GA - Orlando, FL (from February 1979)
AC	Included Charlotte, NC between Atlanta and Orlando (from April 1979)
SK	Brunswick, NJ - Baltimore, MD - Richmond, VA - Charlotte, NC - Atlanta, GA - Orlando, FL (from September 1978, replacing airline cargo shipments from Newark, NJ
NE	Billerica, MA - Alexandria, VA - Atlanta, GA - Oak Ridge, TN (from September 1979).
Airfreight carriers	
BA	Newark, NJ - Charlotte, NC - Atlanta, GA (to August 1979, then RAM carried by NE, see above.)
FE	Atlanta (Georgia Institute of Technology reactor to airport).

Appendix B-4

Site Radiation Monitoring with TLD's

TLD Location	Quarterly exposure, mR 11/3/77 to 2/2/78	2/2/78 to 5/8/78	5/8/78 to 8/7/78	8/7/78 to 11/6/78	11/6/78 to 2/5/79	2/ 5/79 to 5/17/79	5/17/79 to 8/15/79	Annual average exposure, mR (no. of quarterly measurements)
Terminal A								
(1 C)* - office	27	37	24	25	23	29	25	110 (7)
(2) - RAM area	290	220	53	50	38	42	24	410 (7)
Terminal C								
(1 C) - north wall	44	50	29	36	27	40	M†	150 (6)
(2 C) - east wall	32	13	34	37	29	37	M	120 (6)
(3) - inbound RAM (hazardous holding area)	250	74	M	210	74	54	53	480 (6)
(4) - outbound RAM area	34	M	23	23	M	31	20	100 (5)
(5) - east wall between bay door 1 and 2	750	1,090	500	220	230	120	28	1,680 (7)
Terminal D								
(1 C) - hallway between dispatcher's office and breakroom	34	39	32	42	49	40	27	150 (7)
(2 C) - storeroom	43	50	20	25	M	---	--	140 (4)
(3) - terminal side of dispatcher's window	M	160	106	160	190	240	340	800 (6)
(4) - north wall, middle of terminal	410	410	280	360	480	460	120	1,440 (7)
(5) - south wall between bay doors 4 and 5	1,030	2,380	600	590	730	570	230	3,500 (7)
(6) - south wall between bay doors 7 and 8	490	390	310	540	520	760	720	2,130 (7)
(7) - north wall by door 16	-----	2,390	M	1,030	M	380	110	3,910 (4)
(8) - south wall between bay doors 1 and 2	-----	-----	---	-----	130	83	78	390 (3)
(9) - east wall, doors A and B	-----	-----	---	-----	---	300	590	1,780 (2)
(10) - east wall, doors B and C	-----	-----	---	-----	---	230	390	1,240 (2)
(11) - west wall, between doors 2 and 3	-----	-----	---	-----	---	120	120	480 (2)

Appendix B-4 (CONTINUED)

Site Radiation Monitoring with TLD's

TLD Location	Quarterly exposure, mR 11/3/77 to 2/2/78	2/2/78 to 5/8/78	5/8/78 to 8/7/78	8/7/78 to 11/6/78	11/6/78 to 2/5/79	2/ 5/79 to 5/17/79	5/17/79 to 8/15/79	Annual average exposure, mR (no. of quarterly measurements)
Terminal E								
(1 C) - office	-----	15	14	14	12	29	M	67 (5)
(2) - RAM area	-----	53	19	55	17	28	27	130 (6)
Terminal F-1								
(1 C) - Trailer office on north wall	-----	27	24	22	---	---	--	97 (3)
(2) - Trailer office on north wall by RAM	-----	74	21	24	---	---	--	160 (3)
Terminal F-2 (Moved from F-1)								
(1 C) - office	-----	---	---	---	28	38	30	130 (3)
(2 C) - breakroom	-----	---	---	---	35	51	37	160 (3)
(3) - RAM area	-----	---	---	---	M	M	38	---
(4) - RAM area	-----	---	---	---	160	83	41	380 (3)
(5) - RAM area	-----	---	---	---	190	42	35	356 (3)
Terminal G								
(1) - office	-----	77	73	73	70	---	--	290 (4)**
(1 A) - RAM area, terminating bins 3 and 4	-----	---	---	---	---	140	43	370 (2)
(2) - cooler wall, outside	-----	---	---	88	94	---	--	360 (2)**
(2 A) - RAM area, terminating bins 1 and 2	-----	---	---	---	---	130	35	330 (2)
(3 C) - cargo area, SE side of terminal, no RAM	-----	M	14	16	16	18	15	63 (5)
(4) - RAM area outbound	-----	17	18	14	M	29	46	99 (5)

Appendix B-4 (CONTINUED)

Site Radiation Monitoring with TLD's

		Quarterly exposure, mR							
		11/3/77 to 2/2/78	2/2/78 to 5/8/78	5/8/78 to 8/7/78	8/7/78 to 11/6/78	11/6/78 to 2/ 5/79	2/ 5/79 to 5/17/79	5/17/79 to 8/15/79	Annual average exposure, mR (no. of quarterly measurements)
Terminal G (Continued)									
(5)	- RAM area inbound	-----	140	200	41	26	26	17	300 (6)
(6)	- RAM area, terminating bins 2 and 3	-----	66	34	43	130	62	52	260 (6)
(7)	- RAM area, terminating bins 4 and 5	-----	---	---	32	160	240	29	460 (4)
(8)	- left side of pickup door #1	-----	---	---	---	---	89	39	260 (2)
Terminal H									
(1 C)	- office	-----	---	---	---	22	29	24	100 (3)
(2)	- RAM area (now using cage in old Shulman Building)	-----	---	---	---	M	M	42	---
(3)	- RAM area (now using cage in old Shulman Building)	-----	---	---	---	19	M	28	94 (2)
Terminal I									
(1 C)	- office	-----	---	---	---	---	23	18	82 (2)
(3)	- RAM area, post to left of east wall	-----	---	---	---	---	M	18	---

* C denotes control TLD's

† M: missing

** elevated readings due to concrete block materials in wall.

Note: All measurements include natural radiation background.

Appendix C

Monitored RAM Packages

Date	No.	Activity, Ci	Isotope			TI	Category				Terminals
			Mo-99	I-131	Other		Ltd	I	II	III	
Oct. 14-15, 1978	5	96,100	4		1	9.1	-	-	-	5	K (1), D (4)
Nov. 18, 1978	4	4.61	3	1		8.3	-	-	-	4	D
Dec. 16, 19, 1978	3	4.50	2		1	5.5	-	-	1	2	D
Jan. 11, 13, 1979	5	6.01	5			12.5	-	-	-	5	D
Feb. 5, 8, 10, 1979	16	62.2	15		1	31.2	-	-	-	16	D (15), E (1)
Feb. 11, 13, 1979	10	3.17	2	8		5.9	-	-	7	3	D
Mar. 8, 11, 14, 1979	13	5.12	7	2	4	12.1	1	1	4	7	D
Apr. 6, 7, 8, 1979	51	2,000	23	15	13	64.2	10	1	13	27	D (47), C(4)
May 3, 5, 1979	25	12.98	18	6	1	25.1	4	2	7	12	D
June 2, 3, 5, 1979	15	5.80	9	2	4	17.5	-	1	2	12	D (10) C (5)
June 30, 1979	22	18.5	20	2		39.7	-	-	2	20	D
July 27, 28, 1979	20	14.5	11	9		26.5	-	-	7	13	D (18), G (2)
Aug. 15, 1979	3	0.006			3	0.2	1	-	2	-	I
Sept. 1, 1979	19	6.35	9	9	1	16.5	-	-	9	10	D
Sept. 27, 29, 1979	19	15.4	9	9	1	21.9	-	-	9	10	D

Appendix D

Vehicle Monitoring Results

Date	Vehicle #	Route	Radiation levels, mR/hour Cab	Surface	Six ft	Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
October 1978										
14	61663	St. Louis to Atlanta	3.4	57.	14.	160.4	Se-75, I-131	rear 3/4	yes	yes
14	15195	018	10.	44.	5.2	46.3	none	middle	yes	yes
14	61663	Atlanta to Orlando	1.8	48.	11.	92.9	none	rear 3/4	yes	yes
14	15203	086	28.	38.	5.6	94.4	none	full	yes	yes
November 1978										
18	61663	St. Louis to Atlanta	4.9	80.	14.	176.1	Se-75	rear 3/4	yes	yes
18	61663	Atlanta to Orlando	2.5	80.	14.	101.6	Se-75	middle	yes	yes
18	15194	018	16.	34.	4.9	50.9	none	front	yes	yes
December 1978										
14	15149	035	unk	unk	unk	27.2	unk	rear	yes	unk
14	37064	Atlanta to Birmingham	unk	unk	unk	8.8	unk	rear	yes	unk
14	15181	028	unk	unk	unk	17.6	unk	right rear	yes	unk
14	56078	039	unk	unk	unk	5.6	unk	left rear	yes	unk
14	15207	014	unk	unk	unk	unk	unk	unk	unk	yes
16	61663	Atlanta to Orlando	1.8	80.	14.	122.8	Se-75	rear 3/4	yes	yes
16	37064	018	6.3	40.	4.9	41.5	none	full	yes	yes
16	15200	086	7.0	19.	unk	unk(1)	unk	full	---	yes

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour			Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
			Cab	Surface	Six ft					
16	15201	086	14.(2)	unk	unk	unk(1)	unk	full	---	yes
17	15181	028	2.5	44.	unk	93.2	unk	rear	yes	1 missing
17	16705	039	0.5	14.	3.0	35.8	unk	rear	yes	yes
17	15180	014	0.2	14.	unk	16.9	unk	rear	unk	yes
19	16144	028	unk	unk	unk	0.1	unk	right rear	yes	unk
19	15207	014	0.2	2.8	unk	3.2	unk	left rear	unk	yes
January 1979										
11	15181	028	0.07	unk	unk	13.4	unk	right rear	yes	yes
11	15170	039	0.08	unk	unk	unk	unk	middle rear	yes	yes
11	15207	014	0.05	unk	unk	8.0	unk	middle rear	yes	yes
13	61663	St. Louis to Atlanta	6.0(3)	70	8.5	232.2	Se-75,Mo-99 + I-131	full	yes	yes
13	61663	Atlanta to Orlando	1.4	52	unk	121.7		middle	yes	yes
13	15195	018	2.1	45	4.7	71.7	none	rear half	yes	unk
14	15180	015	0.2	75	unk	18.5	unk	rear	yes	unk
14	15181	028	1.5	31	unk	95.3	unk	rear	yes	yes
14	15145	008	0.5	16	0.8	12.2	unk	rear	yes	yes

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour			Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
			Cab	Surface	Six ft					
14	15165	080	0.9	16	1.3	28.1	unk	rear	yes	yes
15	15202	100	1.5	10	0.7	18.5	unk	rear	yes	yes
February 1979										
8	16111	Atlanta to Birmingham	0.1	9.0	unk	7.1	unk	rear	yes	unk
8	15207	014	0.07	18	unk	14.6	unk	rear	yes	yes
8	15194	305	0.2	unk	unk	2.2	unk	rear	yes	yes
8	15181	028	0.1	42	unk	unk	unk	rear	unk	yes
10	61663	St. Louis to Atlanta	2.2	85	9.5	206.9	Se-75,Mo-99 + I-131	full	yes	yes
10	61663	Atlanta to Orlando	1.3	51	8.8	103.1		middle	yes	yes
10	15195	018	14	42	3.3	66.5	none	front	yes	yes
11	XRC 92U	New Brunswick,NJ to Atlanta	12	59	7.1	215	Se-75,Mo-99 + I-131	full	yes	yes
11	15199	086	3.3	unk	unk	unk(4)	unk	rear	yes	yes
11	15182	086	8.8	unk	unk	unk(4)	unk	front mid	no	yes
11	16173	400	2.0	17	unk	44.2	unk	rear	yes	yes
11	15181	028	0.7	34	unk	95.5	unk	rear	yes	yes
11	15175	Atlanta to Birmingham	0.2	7.8	unk	3.0	unk	rear	yes	yes
11	15171	015	0.3	14	unk	23.	unk	rear	yes	yes

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour			Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
			Cab	Surface	Six ft					
11	16727	305	0.3	12	unk	7.3	unk	rear	yes	yes
11	15189	100	1.5	13	unk	14.8	unk	rear	yes	yes
13	15147	Atlanta to Birmingham	0.1	14	unk	1.6	unk	rear	yes	unk
13	15207	014	0.04	17	unk	3.7	unk	rear	yes	yes
13	16144	028	0.1	37	unk	4.2	unk	rear	yes	yes
13	15170	039	unk	unk	unk	0	unk	unk	yes	yes
13	15145	008	0.2	17	unk	8.6	unk	rear	yes	yes
March 1979										
8	15206	035	0.5	9.8	unk	8.3	unk	rear	yes	yes
8	B-5285-78	028	0.05	unk	unk	13.3	unk	rear	yes	none
8	15170	039	unk	unk	unk	2.2	unk	rear	yes	unk
8	16111	Atlanta to Birmingham	0.06	3.3	unk	2.7	unk	rear	yes	unk
8	15207	014	0.04	15	unk	9.0	unk	rear	yes	yes
10	C-71817	St. Louis to Atlanta	0.4	85	9.3	230.1	none	mid rear	yes	yes
10	XRC 92U	New Brunswick,NJ to Atlanta	9.0	unk	unk	unk(5)	unk	full	yes	yes
10	15195	018	2.9	52	5.1	79.4	none	rear	yes	unk

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour			Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
			Cab	Surface	Six ft					
10	15199	086	2.2	17	unk	29.0	unk	rear	no	yes
10	15201	086	4.2(2)	62	unk	57.8	unk	rear	yes	yes
11	15181	028	0.8	65	unk	92.3	unk	rear	yes	yes
11	15203	080	1.2	9.8	unk	28.0	unk	rear	yes	yes
11	15180	015	0.4	18	unk	18.8	unk	rear	yes	yes
11	16705	039	1.7	37	3.0	46.3	unk	rear	yes	yes
11	15208	100	0.09	9.8	unk	12.8	unk	rear	yes	yes
11	15205	008	0.3	8.4	17.	0.8	unk	rear	yes	yes
April 1979										
5	15170	305	0.1	unk	unk	2.7	unk	rear	yes	yes
5	15207	014	0.04	40.	unk	23.6	unk	r. rear	yes	yes
5	15181	028	0.1	50.	unk	19.8	unk	r. rear	yes	yes
7	15174	081	0.1	unk	unk	0.3	unk	l. rear	yes	not req.
8	XRC-92U	New Brunswick,NJ to Atlanta	1.9 3.4(6)	51.	unk	unk	unk	full	yes	yes
8	15171	015	0.4	16.	unk	28.4	unk	r. rear	yes	yes
8	15181	028	1.2	57.	unk	67.5	unk	rear	yes	yes

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour Cab	Surface	Six ft	Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
8	16711	400	1.6	29.	unk	39.9	unk	rear	yes	yes
8	15165	080	0.6	16.	unk	21.9	unk	rear	yes	yes
8	15028	100	0.7	10.	unk	13.7	unk	rear	yes	yes
8	15205	008	0.1	16.	unk	12.1	unk	1. rear	yes	yes
10	15149	035	0.6	15.	unk	8.1	unk	rear	yes/3	Displayed
10	15207	014	0.04	16.	unk	3.2	unk	1. rear	yes	yes
10	15194	305	0.05	---	---	---	unk	rear	yes	not req.
10	15181	028	0.05	3.0	unk	6.3	unk	rear	yes	Yes(7)
May 1979										
3	15207	014	0.05	32.	1.2	25.4	unk	r.rear	yes	yes
3	15170	305	0.08	8.0	0.2	2.3	unk	rear	yes	yes(7)
3	15194	SC Express	0.04	0.09	0.08	0.1	unk	1. rear	yes	not req.
3	15181	028	0.15	40.	unk	22.	unk	r. rear	yes	yes
5	71817	St. Louis to Atlanta	1.2	100.	unk	229.1	none	middle	yes	yes
5	71817	Atlanta to Orlando	1.1	98.	10.	189.3	none	middle	yes	yes
5	15180	086	0.2(2)	0.2	unk	0.2	unk	r. rear	yes	yes
5	15180	086	6.5	56.(2)	7.5(2)	87.6	unk	rear	no	yes

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour Cab	Surface	Six ft	Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
6	XRC-92U	New Brunswick,NJ to Atlanta	3.1	50.	unk	172.5	unk	full	yes	yes
6	XRC-92U	Atlanta to Orlando	2.1	50.	unk	81.8	unk	rear	yes	yes
6	15189	108	0.1	4.5	unk	3.1	unk	rear	yes	yes
6	16725	400	2.0	17.	unk	40.4	unk	rear	yes	yes
6	15181	028	0.6	56.	3.0	72.6	unk	rear	yes	yes
6	15180	015	0.4	16.	unk	31.5	unk	rear	yes	yes
6	15173	080	0.6	15.	unk	21.3	unk	rear	yes	yes
6	15205	008	0.4	17.	1.	10.4	unk	rear	yes	yes
6	15178	011	0.1	3.0	0.2	2.5	unk	1. rear	yes	yes
6	15208	100	0.8	10.	1.0	13.9	unk	rear	yes	yes
6	912	039	0.1	4.1	0.1	2.5	unk	1. rear	yes	yes
8	15207	014	0.04	9.0	unk	4.1	unk	rear	yes	yes
8	15181	028	0.07	16.	unk	8.6	unk	rear	yes	yes
31	15170	305	0.4(2)	3.0	unk	2.2	unk	r. rear	yes	yes
31	15207	014	0.07	40.	2.5	23.2	unk	r. rear	unk	yes
31	16144	028	0.09	50.	unk	16.7	unk	r. rear	unk	yes

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour			Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
			Cab	Surface	Six ft					
June 1979										
2	71817	St. Louis to Atlanta	0.4	120.	unk	238.	Se-75	middle	yes	yes
2	71817	Atlanta to Orlando	0.4	120.	14.	193.2	Se-75	middle	yes	yes
2	15213	086	9.0	46.	unk	56.5	unk	middle	yes	yes
2	15209	086	4.0	17.	unk	30.7	unk	full	no	yes
3	16725	400	unk	unk	unk	41.9	unk	rear	yes	unk
3	15181	028	0.6	36.	2.4	72.1	unk	rear	yes	yes
3	15180	015	0.4	16.	1.3	29.7	unk	rear	yes	yes(7)
3	15199	081	0.1	unk	unk	0.9	unk	rear	yes	yes
3	15178	011	0.1	4.1	0.2	1.6	unk	rear	unk	yes
3	15209	080	0.5	17.	1.2	19.7	unk	rear	no	yes
3	912	039	0.04	0.7(2)	unk	0.1	unk	rear	unk	yes
3	15186	051	0.2	1.3	0.2	1.5	unk	1. rear	unk	yes
3	15205	008	0.4	15.	0.8	10.	unk	rear	yes	yes
3	15208	100	1.0	16.	1.1	16.3	unk	rear	yes	yes
5	15165	024	0.09	1.8	unk	2.9	unk	rear	yes	yes
6	15165	024	0.5	15.	unk	12.	unk	rear	yes	yes

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour Cab	Surface	Six ft	Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
28	15207	014	0.1	41.	2.9	25.4	unk	1. rear	yes	yes(7)
28	16144	028	0.1	20.	2.2	17.6	unk	rear	yes	yes(7)
28	37064	SC Express	0.08	unk	unk	---	unk	rear	yes	not req.
30	15192	081	0.3	17.	unk	6.5	unk	rear	no	yes
30	15209	081	2.5	12.	unk	20.1	unk	rear	no	yes
30	15200	081	7.0	56.	unk	72.	unk	middle	no	yes
July 1979										
1	71483	Charlotte, NC to Atlanta(8)	0.5	85.	10.	350.1	Se-75	rear	yes	yes
1	71483	Atlanta to Orlando	0.5	85.	10.	218.3	Se-75	rear	yes	yes
1	15120	108	0.3	unk	unk	3.	unk	rear	yes	yes
1	16144	028	0.6	61.	4.	91.5	unk	rear	yes	yes(7)
1	15180	015	0.4	17.	unk	39.	unk	rear	yes	yes
1	15165	080	0.8	17.	unk	22.2	unk	rear+2 sides	yes	yes
1	15205	008	0.3	14.	0.6	10.6	unk	1. rear	yes	yes
1	15216	100	0.8	17.	1.4	22.7	unk	rear	yes	yes
1	15214	039	0.6	40.	2.5	45.7	unk	rear	no	yes
26	15207	014	0.06	52.	2.0	24.6	unk	rear	yes	yes

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour Cab	Surface	Six ft	Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
26	15170	305	0.05	unk	unk	2.2	unk	rear	yes	yes
26	37064	028	0.09	40.	unk	19.9	unk	rear	no	yes
28	71483	Atlanta to Orlando	0.5	95.	10.	202.	Se-75 + Co-57	rear	no	yes
28	15180	086	0.6	30.	unk	6.6	unk	rear	no	yes
28	XRC92U	New Brunswick,NJ to Atlanta	3.5 4.0(6)	unk	unk	125.5	none	mid rear	yes	yes
29	15165	086	8.0	75.	unk	105.8	unk	rear	yes	yes
29	15164	005	0.3	3.0	unk	2.0	unk	rear	yes	yes
29	15210	103	0.5	10.	unk	2.5	unk	rear	yes	yes
29	16725	400	2.6 4.0(6)	18.	unk	51.2	unk	full	yes	yes
29	16144	028	1.8	75.	4.5	104.1	unk	rear	yes	yes(7)
29	15215	080	0.9	15.	1.3	22.4	unk	rear	yes	yes
29	15180	015	0.9	16.	1.6	39.3	unk	rear	yes	yes
August 1979										
30	15170	305	0.2	0.4	unk	2.2	unk	rear	yes	yes
30	15207	014	0.1	42.	unk	18.9	unk	rear	yes	yes
30	16144	028	0.4	8.	unk	17.7	unk	rear	yes	yes

Appendix D (cont'd.)

Date	Vehicle #	Route	Radiation levels, mR/hour			Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
			Cab	Surface	Six ft					
31	15165	024	0.09	3.5	unk	1.4	unk	rear	unk	yes
31	15218	100	0.05	unk	unk	0.1	unk	rear	unk	yes
September 1979										
1	15199	086	9.0	75.	unk	113.0	unk	full	yes	yes
1	15199	037	2.0(2)	31.(2)	unk	7.3	unk	rear	yes	yes
1	XRC92U	New Brunswick,NJ to Atlanta	1.5	35.	unk	114.	none	rear	yes	yes
3	15180	015	0.7	16.	1.5	36.6	unk	rear	yes	yes
3	16144	028	1.0	35.	2.5	104.7	unk	rear	yes	yes
3	15204	016	0.4	4.5	unk	3.0	unk	rear	yes	yes
3	15173	080	0.6	12.	0.9	21.	unk	rear	yes	yes
3	15148	081	0.3	1.3	unk	1.0	unk	rear	yes	yes
3	16724	400	0.9	18.	2.0	43.	unk	rear	yes	yes
3	15189	100	0.8	12.	0.8	21.6	unk	rear	no	yes
4	15214	039	0.05	0.1	unk	0.4	unk	rear	yes	yes
4	15145	008	0.6	9.0	0.9	11.6	unk	rear	yes	yes
8	541	Turkey Point Florida to Ohio (Spent Fuel)	0.07	3.5	1.2	4.0	Cs-137, Co-57 + Co-60	trl cask	yes	yes

Appendix D (cont'd.)

	Date	Vehicle #	Route	Radiation levels, mR/hour Cab	Surface	Six ft	Transportation Index	Removable Contamination	Package Placement	Proper Shipping Documents	Placards
8		536	Turkey Point Florida to Ohio (Spent Fuel)	0.04	2.8	0.9	8.0	none	trl cask	yes	yes
20		532KOG	New Brunswick,NJ to Atlanta	2.0	unk	unk	54.2	I-131	front	yes	yes
27		16144	028	0.09	41.	unk	15.4	unk	rear	yes	yes
27		15207	014	0.07	17.	unk	20.0	unk	rear	yes	yes
27		15170	305	0.1	3.0	unk	2.3	unk	rear	yes	yes
29		30603	Atlanta to Orlando	0.08	120.	15.	211.1	Se-75,Mo-99 + Co-57	middle	yes	yes
30		55	Billerica,MA to Atlanta	0.03	16.	1.1	unk(9)	none	front	yes	yes
30		15209	015	0.5	17.	1.0	32.5	unk	rear	yes	yes
30		15217	080	1.1	15.	1.1	21.4	unk	middle	yes	yes
30		15214	028	1.0	48.	unk	107.7	unk	rear	yes	yes
30		16724	400	0.3	55.	3.5	44.4	unk	rear	yes	yes
30		15145	008	0.6	17.	1.1	11.0	unk	rear	yes	yes
30		15189	100	1.7	14.	1.3	15.1	unk	rear	yes	yes

Notes: (1) TI of 98.8 was loaded on vehicles 15200 and 15201. Unknown what portion of TI on which vehicle. RAM delivered to Atlanta by charter aircraft.

(2) Some contribution from nearby RAM affected reading.

(3) Ten Mo-99 packages found between the lead shield and front of truck bed contributed to high cab reading.

(4) TI of 89.0 was loaded on vehicles 15199 and 15182. Unknown what portion of TI on which vehicle. RAM delivered to Atlanta by charter aircraft. All shipping documents with vehicle 15199.

(5) Total TI on vehicle is unknown. A total TI of 111.5 was unloaded in Atlanta.

(6) Second reading for passenger's seat.

(7) Driver was reminded to display placards.

(8) Squibb and Mallinckrodt RAM on vehicle returning to Atlanta from Charlotte, N.C.

(9) TI on vehicle is unknown; however, a TI of 117.7 was unloaded in Atlanta. Remainder of RAM was destined for Tennessee.

Appendix E-1

Three-month Summary of RAM Shipments at Airline Terminal C, Atlanta, Outbound

Date	Shipper	Destination	Isotope	Total TI	Category	Packages in shipment
January, 1979						
18	Skycab	Shreveport, LA	Mo-99	4.6	III	3
19	Oak Ridge NL	Spokane, WA	Xe-133	0.1	II	1
21	Medi Physics	Jackson, MS	I-123	0.1	II	1
24	Medi Physics	Jackson, MS	I-123	0.1	II	1
25	Skycab	New Orleans, LA	Mo-99, I-131	4.1	III	2
	Merrell Research Center	Boston, MA	C-14	---	I	1
	Capintec, Inc	Jackson, MS	Cs-137, Co-57	---	I	1
	New England Nuclear	Birmingham, AL	H-3	---	I	1
			Ga-67	0.1	II	1
		New Orleans, LA	H-3	---	I	1
26	Skycab	New Orleans, LA	Mo-99	7.5	III	3
29	3M	Monroe, LA	Yb-169	0.1	II	1
February, 1979						
1	Skycab	Shreveport, LA	Mo-99	4.6	III	3
9	Skycab	Knoxville, TN	I-125	---	Ltd	1
9	Oak Ridge NL	Ontario, Canada	Xe-133	0.1	II	1
11	Medi Physics	Jackson, MS	I-123	0.1	II	1
13	Harshaw Chemical	Oak Ridge, TN	Am-241	---	Ltd	1
14	Diagnostic Isotopes	San Francisco, CA	In-111	0.2	II	1
	Skycab	Birmingham, AL	I-131	2.8	III	1
16	Becton Dickson	Birmingham, AL	I-125	---	Ltd	1
	Medi Physics	S Plainfield, NJ	Mo-99	6.2	III	1 (Type B)
		Glendale, CA	Mo-99	5.0	III	1 (Type B)
		Emeryville, CA	Mo-99	3.0	III	1 (Type B)

Appendix E-1 (cont'd.)

Date	Shipper	Destination	Isotope	Total TI	Category	Packages in shipment
	Skycab	Knoxville, TN	Cs-137	---	I	1
	Exxon (Doraville, GA)	Billerica, MA	Cr-51	---	I	1
19	Diagnostic Isotopes	San Francisco, CA	In-111	0.5	II	1
24	Skycab	New Orleans, LA	Mo-99	1.6	III	1
25	Medi Physics	Knoxville, TN	Ga-67	0.3	II	1
26	Diagnostic Isotopes	San Francisco, CA	In-111	0.4	II	1
	Micromedic Systems	Detroit, MI	I-125	---	Ltd	1
	New England Nuclear	Baltimore, MD	Tl-201	---	I	1
			Ga-67	0.1	II	1
		Tampa, FL	Tl-201	---	I	3
27	Skycab	Chattanooga, TN	Se-75	0.4	II	1
March, 1979						
5	Medi Physics	Jackson, MS	I-123	0.1	II	1
6	Oak Ridge NL	Palmdale, CA	Xe-133	0.1	II	1
	Diagnostic Isotopes	San Francisco, CA	Ga-67	0.9	II	1
	Medi Physics	Jackson, MS	I-123	0.1	II	1
7			I-123	0.1	II	1
	Diagnostic Isotopes	San Francisco, CA	Ga-67	0.5	II	1
21	Skycab	Lexington, KY	I-125	---	Ltd	1
	Medi Physics	Jackson, MS	I-123	0.1	II	1

Appendix E-1 (cont'd.)

Date	Shipper	Destination	Isotope	Total TI	Category	Packages in shipment
April, 1979						
4	New England Nuclear	Birmingham, AL	Tl-201	---	I	1
5	Delta Airlines	N Billerica, MA	Tl-201	---	I	1
			Ga-67	2.0	III	1
	Skycab	Denver, CO	Mo-99	10.0	III	8
			I-125	---	I	3
		Memphis, TN	Mo-99	6.1	III	3
			I-131	0.8	II	1
			I-125	---	Ltd	1
			Co-57/I-131/ I-125	0.5	II	1
		San Francisco, CA	I-131	0.3	II	1
		Houston, TX	Mo-99	2.2	III	1
			I-131	0.3	II	1
		Los Angeles, CA	I-125	---	Ltd	1
		Dallas, TX	Mo-99	6.1	III	6
			I-125	---	Ltd	1
	Medi Physics	S Plainfield, NJ	Mo-99	9.4	III	1 (Type B)
		Emeryville, CA	Mo-99	3.4	III	1 (Type B)
		Glendale, CA	Mo-99	6.0	III	1 (Type B)
		Arlington, Ht, IL	Mo-99	2.6	III	1 (Type B)
17	Skycab	Lexington, KY	Co-57	0.2	II	1
		Chattanooga, TN	I-131	1.3	III	1

Notes: 1. Data were obtained from air bills and shipper's certificates provided by outbound office personnel; inspection was on April 5-6, 1979. The RAM Shipment data may not include all outbound RAM during subject period.

2. On April 5, RAM was carried to Atlanta by Skycab van from Squibb (New Jersey). All other inbound shipments transferred from another flight.
3. Strike at United Airlines increased number of shipments through Atlanta in April.

Appendix E-2

Monthly Summary of RAM Shipments at Airline Cargo Terminal G, Atlanta, Terminating

Date	Origin	Isotope	Curie	TI	Category Ltd	I	II	III	Remarks
June 1979									
5	STL	Mo-99	3.2	4.0				2	
	EWR	Mo-99	7.3	8.0				5	overpack
		I-131	0.013						
6	PIT	Cs-137	0.001						
		Co-60	0.0001	---		1			overpack
		Co-57	0.001						
10	LGA	I-131	0.005	0.7				1	
12	STL	Mo-99	3.2	4.0				2	
	EWR	Mo-99	7.6	6.3				4	overpack
13	STL	I-131	0.061	1.0				1	
		I-125	0.0001	---	1				
19	STL	Mo-99	3.5	4.5				2	
	EWR	Mo-99	7.3	5.8				4	overpack
			0.56	1.9				1	
26	STL	Mo-99	3.5	4.5				2	
	EWR	Mo-99	7.6	6.3				4	overpack
28	IAH	Cs-137	0.00007	---	1				
29	EWR	Mo-99	unknown	8.0				5	overpack
TOTALS			44.	55.0	2	1	0	33	

Notes: 1. Data were obtained from airbills and restricted articles forms.

2. Overpacks from Skycab (Squibb RAM - Mo-99 from EWR) may contain two Mo-99 packages each as indicated by two Squibb billing numbers.

Origin-Destination Codes

EWR	Newark, NJ
TLH	Tallahassee, FL
STL	St. Louis, MO
SAT	San Antonio, TX
SFO	San Francisco, CA
ATL	Atlanta, GA
PHL	Philadelphia, PA
LGA	New York, NY
PIT	Pittsburgh, PA
IAH	Houston, TX
CLT	Charlotte, NC
SDF	Louisville, KY
JFK	New York, NY

Appendix E-3

Monthly Summary of RAM Shipments at Airline Cargo Terminal G, Atlanta, Outbound

Date	Origin	Destination	Isotope	Curie	TI	Category Ltd	I	II	III
August 1979									
2	EWR	SAT	Mo-99	0.72	2.2				1
2	EWR	SAT	I-125	0.001	---	1			
2	TLH	SFO	Ni-63	0.008	---	1			
3	STL	CLT	NOS	0.037	1.0				1
3	EWR	SAT	Mo-99	2.8					1
3	EWR	SAT	Mo-99	2.3	5.7				1
3	EWR	SAT	Se-75	0.0015				1	
7	EWR	SAT	Mo-99	1.7	2.5				1
11	EWR	SAT	Mo-99	2.8	2.9				1
11	EWR	SAT	Mo-99	2.8	2.9				1
11	EWR	SAT	I-125	0.001	---	1			
14	EWR	SAT	Mo-99	1.7	2.5				1
16	EWR	SAT	Mo-99	0.72	2.2				1
16	EWR	SAT	I-125	unk	---	1			
18	EWR	SAT	Mo-99	5.7	5.9				2
18	EWR	SAT	Co-57	unk	---	1			
19	EWR	SDF	Mo-99	1.7	2.5				1
21	EWR	SAT	Mo-99	1.7	2.5				1
23	EWR	SAT	Mo-99	0.72	2.2				1
23	EWR	SAT	I-131	0.0048	1.1				1
23	EWR	SAT	I-125	0.001	---	1			
24	EWR	SAT	Mo-99	5.1	5.4				2
25	EWR	SAT	Mo-99	2.8	2.9				1
25	EWR	SAT	Mo-99	2.8	2.9				1
25	ATL	PHL	Xe-133	0.50	---		1		
28	EWR	SAT	Mo-99	1.7	2.5				1
30	EWR	SAT	Mo-99	0.72	2.2				1
30	EWR	SAT	Mo-99	0.72	2.2				1
30	EWR	SAT	I-125	0.001	---	1			
31	EWR	SAT	Mo-99	2.3	5.4				1
31	EWR	SAT	Mo-99	2.8					1
TOTALS				45.1	59.6	7	1	1	24

Notes: 1. NOS - not otherwise specified.

2. Data were obtained from restricted articles on board notification forms.

Appendix E-4

Monthly RAM Shipments at Airline B,
Atlanta, Terminating

Date	Isotope	Curie	TI	Category Ltd	I	II	III	Remarks
June 1979								
1	NOS	unk	unk					3 pcs.
4	NOS	unk	unk					2 pcs.
5	NOS	unk	unk					3 pcs. (4th missing)
6	NOS	unk	unk					4 pcs.
	NOS	unk	unk					2 pcs.
7	NOS	unk	unk					1 pc.
13	NOS	unk	unk					1 pc.
14	I-131	0.008	0.2			1		2 pcs.
16	NOS	unk	unk					4 pcs.
18	I-131	0.19	1.5				1	
19	I-131	0.043	1.0				1	
		0.019	0.6			1		
21	Cr-51	0.001	0.1			1		
	I-131	0.22	1.4				1	
	I-131	0.083	0.6			1		
	I-125	0.0002	---	1				
25	NOS	unk	unk					1 of 4 pcs.
26	NOS	unk	unk					8 pcs.
	NOS	unk	unk					3 pcs. (1 short)
27	NOS	unk	unk					5 pcs.
28	NOS	unk	unk					1 pc.

Note: Data were obtained from air bills. All RAM were from Mallinckrodt, St. Louis, MO. Some air bills did not reflect data (marked NOS - not otherwise specified), listed here as "unknown."

Appendix E-5

Monthly Summary of RAM Shipments at Airline B,
Atlanta, Outbound

Date	Origin	Destination	Isotope	Curie	TI	Category Ltd	I	II	III	Remarks
June 1979										
10	ATL	Elgin AFB, FL	I-125	0.00001	---	1				Amersham RAM
unk	ATL	Dothan, AL	I-125	0.002	---		1			

Note: Data were obtained from air bills.

Appendix E-6

Five-Month Summary of RAM Shipments, Airfreight Carrier E, Atlanta

1979 Date	Origin	Destination	Isotope	Curie	TI	Category Ltd	I	II	III
April									
17	Technical OPN Burlington, MA	Oak Ridge, TN	depleted U-238	0.031	0			2	
23	Oak Ridge, TN	Source Prod. Equip., LA	Ir-192	7,400	2.3				1
17	Technical OPN, Burlington, MA	Oak Ridge, TN	depleted U-238	0.031	0			2	
27	Davis Besse Nuclear Sta., Oak Harbour, OH	Crystal River, FL	Co-58 Co-60	0.0000001	-		1		
May									
1	U.S. Radium Corp., Bloomsburg, PA	General Time, Athens, GA	H-3	9.3	-	1			
3	Oak Ridge, TN	Gamma Ind., Baton Rouge, LA	Ir-192	7,900	5.1				1
30	Technical OPN, Burlington, MA	Oak Ridge, TN	depleted U-238	0.031	0			1	
July									
19	"	"	"	0.031	0			1	
August									
18	"	"	"	0.031	0			1	
23	U.S. Radium Corp., Bloomsburg, PA	Savannah, GA	H-3	125	0		1		
TOTALS				15,000.	7.4	1	2	7	2

Note: No shipments were reported during June.

Appendix E-7

Monthly Summary of RAM Shipments at Airfreight Carrier F, Atlanta

Date	Origin	Destination	Isotope	Curie	TI	Category Ltd	I	II	III	Remarks
June 1979										
1	Oak Ridge	JFK-Belgium	U-235	0.001	---		2			(1)
1	Oak Ridge	JFK-Belgium	U-238	0.001	---	1				(1)
1	Oak Ridge	JFK-Belgium	Pu-244	0.001	---		1			(1)
1	Oak Ridge	JFK-Belgium	Am-243	0.004	0.7			1		(1)
1	Oak Ridge	JFK-Belgium	Cm-248	0.00025						
5	Oak Ridge	Los Angeles, CA	H-3	50,000	---		1			
6	Benton Dickson	JFK-unk	I-125	0.000053	---	3				
8	Oak Ridge	SFO Industrial Nuclear	Ir-192	3,000	0.4			1		(1)
13	Westinghouse, Columbia, SC	SFO Southwest Nuclear	U	0.1 (2)	---		1			(1)
TOTALS				53,000	1.1	4	5	2	0	

Notes: 1. By truck to Atlanta; the package on June 13 was a drum that contained clothing and respirators.

2. Shipper's certificate did not indicate whether curies or millicuries.

3. No shipments occurred June 14-30.

Appendix E-8

Two-Month Summary of RAM Shipments at Airfreight Carrier H, Atlanta

Date, 1979	Origin	Destination	Isotope	Curies	TI	Category Ltd	I	II	III
June									
1	Lockheed, Marietta, GA	Lockheed, CA	depl U (LSA)	0.013	0.2			2	
15	Atlanta, GA	Sentrol Systems, WA	Kr-85	0.50	1.0			1	
18	SRP, SC	Rockwell Int., CA	cont. equip MFP	$<10^{-6}$	---	1			
				0.51	1.2	1		3	
July									
2	NL Ind., NY	Lockheed, GA	depl U	0.012	0.2			1	
				0.012	0.2			1	
3	unknown (ORD)	Atlanta, GA	Co-60, Mn-54	6×10^{-6}	0.1			1	
6	NL Ind., NY	Lockheed, GA	depl U	0.013	0.2			1	
				0.013	0.2			1	
				0.013	0.2			1	
	Lockheed, GA	Lockheed, CA		0.018	0.2			1	
				0.018	0.2			1	
10	NL Ind., NY	Lockheed, GA		0.015	0.2			1	
				0.015	0.2			1	
				0.015	0.2			1	
12	Lockheed, GA	Lockheed, CA		0.036	0.2			1	
				(total)	0.2			1	
					0.2			1	
17	Lockheed, GA	Lockheed, CA		0.037	0.2			1	
				(total)	0.2			1	
					0.2			1	
30	Beckman, GA	Beckman, CA	Cs-137	0.00004	---	1			
				0.20	3.3	1		17	

Appendix E-9

Three-Month Summary of RAM Shipments at Airfreight Carrier J,*
Atlanta, Outbound

Date, 1979	Destination	TI
June 5	FL	0.3
	AL/MS	0.7
6	FL	0.1
	OH	3.1**
8	FL	0.2
	AL/LA	0.2
9		0.2
11	OH	2.0
12	FL	0.7
	AL/MS	0.5
13	AL/LA	1.0
16	FL	0.3
18	OH	2.0
19	FL	0.2
	AL/MS	0.2
	AL/LA	0.2
20	FL	0.2
	AL/MS	0.5
22	FL	0.2
23	FL	0.2
25	OH	2.0
26	FL	1.6
27	AL/MS	0.5
	OH	0.5
28	FL	0.1
29	FL	0.1
30	FL	0.1
		17.8 (27 flights)
July 2	OH	2.0
3	FL	0.8
4	FL	0.3
6	AL/MS	0.1
7	FL	0.8
10	FL	0.3
	AL/MS	0.1
11	FL	0.2
13	FL	0.2
14	FL	0.5

Appendix E-9 (cont'd)

Date, 1979	Destination	TI	
17	FL	0.4	
20	FL	0.5	
21	FL	0.4	
23	OH	5.4	
24	FL	0.3	
25	AL/TN	0.2	
31	FL	1.9	
	AL/LA	0.1	
	AL/TN	0.1	
	OH	5.0	
		19.6	(20 flights)
August			
1	FL	0.1	
	AL/MS	0.1	
2	FL	1.0	
3	AL/MS	0.2	
4	FL	0.3	
	AL/LA	0.2	
6	OH	2.0	
8	FL	0.3	
	AL/MS	0.1	
11	FL	0.6	
13	OH	2.0	
14	FL	0.3	
	AL/MS	0.2	
16	FL	0.1	
	AL/MS	0.2	
17	FL	0.6	
	AL/LA	0.1	
18	FL	0.3	
20	OH	2.0	
21	FL	0.2	
23	FL	0.3	
25	FL	0.3	
27	OH	3.0	
28	FL	0.6	
29	FL	0.2	
29	AL/LA	0.3	
31	OH	3.7	
	FL	0.1	
		19.4	(28 flights)

---

* Charter service for Airborne Air Freight.
Data obtained from hazardous material pilot notification forms.

** Mo-99; radioisotopes in all other shipments are unknown with the exception indicated in the Notes.

Notes:
1. Outbound data were obtained from records that list RAM with TI recorded on label; no information was obtained for RAM terminating in Atlanta.
2. Flights to AL/MS and AL/LA were subsequently discontinued.
3. The following RAM unloaded in Atlanta was checked on September 19, 1979: AMERSHAM, Arlington Ht., IL, Na-22, II, 0.2 TI; C-14, I; unknown, Ltd. RAM was immediately loaded on another aircraft for Florida.

Appendix F-1

Transportation of Radioactive Waste from Nuclear Power Stations
Through Georgia for Burial at Barnwell, SC,
May 1 to August 31, 1979

State	Shipper	Carrier*	Number of Shipments	Total Activity	Range of Activity per Shipment, Ci
Alabama	Farley	A(28)	28	2343	720-0.10**
	Brown's Ferry	K(57) D(7)	64	1467	390-0.06
Arkansas	Arkansas I	K(7)	7	44	39-0.096
Florida	Crystal River, St. Lucie, and Turkey Point	A(36) D(9) K(30)	75	215	44-0.0009
Georgia	Hatch	A(11) D(8) K(10)	29	247	80-0.0003
Illinois	Dresden, Quad Cities and Zion	A(1) B(17) C(71)	89	681	175-0.4
Iowa	Duane Arnold	C(11)	11	108	12-5.8
Michigan	D.C. Cook	B(3) C(2)	5	4	0.9-0.1
Minnesota	Monticello	D(8)	8	243	67-20
Wisconsin	Point Beach	D(5)	5	2.6	1.0-0.1

---

* Carrier is identified by letter; number of shipments is in parentheses.

** Burial record of one shipment had 576 curies, but shipment record with vehicle had activity of 0.576 curies; the latter value is used here.

APPENDIX F-2

Transportation of Miscellaneous Radioactive Waste Through
Georgia for Burial at Barnwell, SC,
May 1 - August 31, 1979

State	Shipper	Date, 1979	Carrier*	Activity, Ci
Alabama	Wyle Lab	May 10	O	0.006
	Rad Safety, U of AL	May 18	R	0.5
	U.S. Army	July 6	T	0.000012
	Radiology Consultants	July 13	U	0.008
	Wyle Lab	July 20	O	0.00030
Arizona	U.S. Air Force	May 17	P	0.6
California	U.S. Air Force	May 1-4	L Q J	0.003
		June 19	M	0.000007
		June 25	J	0.00003
		July 9	J	0.00085
	U.S. Army	June 20	M	0.050
		July 19	J	0.016
		July 25	V	0.0042
		July 31	W	1.4
Colorado	U of CO	June 19	L	0.2[1]
Florida	UG Tampa	May 14	M	0.002
	U of FL	May 18	K	43,000[2]
	U of FL	May 21	K	43,000[2]
	Navy	May 31	R	0.5
	Smith Kline Clinical Lab, Miami	June 19	H	unk[3]
	North American Biologicals, Miami	June 19	H	unk[3]
	U.S. Air Force	July 5	S	0.000002
	Scott Luminous	July 19	H	0.45
	U.S. Air Force	August 2	Q	0
	Farm Land Industries	August 14	N	0.43
	U.S. Air Force	August 28	S	0.038
Georgia	Ft Gordon	May 5 & 11	A (2)	0.015
	Med Col of Georgia	May 12	A	0.075[4]
	Morehouse Col	May 18	Q	0.001[4]
	Georgia Tech			2.1[4]
	Emory U			0.15[4]
	Med Col of Georgia	July 16	unk	shipments
	Ft Gordon	July 16	unk	rejected

APPENDIX F-2 (CONTINUED)

State	Shipper	Date, 1979	Carrier	Activity, Ci
	Med Col of Georgia	July 17	A	0.002
	Ft Gordon	July 17	A	0.0015
	Med Col of Georgia	July 26	A	0.050
	U.S. Army	August 2	R	0.003
	U.S. Air Force	August 8	unk	0.0014
	Med Col of Georgia	August 28	A	0.022
Illinois	IIT Research	June 18	C	0.9
Louisiana	Source Prod & Equip	May 18	S	0.081
	U.S. Air Force	July 2	L	0.000012
	Source Prod & Equip	August 20	T	0.22
	U.S. Air Force	August 21	N	0.000002
Michigan	U.S. Air Force	May 4	I	0.001
	Howmet Turbine Corp	May 14	F	0.001
	BASF Wyandotte	July 23	F	0.017
Missouri	Combustion Eng	May 31	K	0.015
	U of MO	June 26	K	0.22
	Mallinckrodt	June 26	K	0.30
	U.S. Air Force	August 8	F	0.52
	Mallinckrodt	August 10	K	1.2
New York	Seneca Army Depot, Romulus	June 20	I	0.001[5]
Tennessee	TNS Inc, Jonesboro	June 19	E	unk[6]
Texas	U.S. Air Force	May 1-21	F (3) L	0.21[7]
	DuPont	May 7	N	0.003[8]
	Todd Research	May 11	D	0.70
	U.S. Air Force	June 1	I (2)	24
		July 13	L	0.000001
		July 16	I	0.00018
		July 26	I	0.00019
		August 6	I	0.00009
		August 13	I	0.000038
	U.S. Army	August 21	L	0.7
	U.S. Air Force	August 23	L	0.000001
		August 24	T	0.000013
		August 28	G	0.000007
Utah	U.S. Air Force	May 4	F	0.001

Notes: 1 Driver picked up RAM from South Augusta terminal; it is not known if original driver came through Georgia except at Augusta.

2 Sealed Cs-137 source.

3 Driver picked up RAM from Clearwater SC terminal; however, load included 69 drums containing I-125 in liquid from two companies in Miami, FL, that were probably transported through Georgia.

4 Consolidated trailer load.

5 Driver picked up H-3 in liquid at Augusta terminal. Shipment was rejected.

6 Normally, waste from TNS Inc. does not go through Georgia; however, burial site was closed on June 15, hence driver took load to North Augusta terminal and then delivered it to Barnwell on June 19, 1979.

7 29 drums of May 21 shipment were rejected.

8 Shipment of 50 containers was rejected and returned to Texas.

* carrier is identified by letter; number of shipments is in parentheses if more than one

NRC FORM 335 (7-77) U.S. NUCLEAR REGULATORY COMMISSION

BIBLIOGRAPHIC DATA SHEET

1. REPORT NUMBER *(Assigned by DDC)*: NUREG/CR-2033

4. TITLE AND SUBTITLE *(Add Volume No., if appropriate)*: Transportation of Radioactive Material in Georgia
Subtitle: October 1978 - September 1979

2. *(Leave blank)*

3. RECIPIENT'S ACCESSION NO.

7. AUTHOR(S): *M.W. Carter, J.T. Gasper, B. Kahn

5. DATE REPORT COMPLETED: MONTH March YEAR 1981

9. PERFORMING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*:
*Office of Interdisciplinary Programs
Georgia Institute of Technology
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Under Subcontract to
State of Georgia
Department of Human Resources
47 Trinity Avenue
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DATE REPORT ISSUED: MONTH May YEAR 1981

6. *(Leave blank)*

8. *(Leave blank)*

12. SPONSORING ORGANIZATION NAME AND MAILING ADDRESS *(Include Zip Code)*:
Office of State Programs
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555
(Sponsored jointly with U.S.Department of Transportation)

10. PROJECT/TASK/WORK UNIT NO.

11. CONTRACT NO.: FIN B1639 and B1327

13. TYPE OF REPORT: Transportation surveillance study (2nd year)

PERIOD COVERED *(Inclusive dates)*: October 1978 thru September 1979

15. SUPPLEMENTARY NOTES

14. *(Leave blank)*

16. ABSTRACT *(200 words or less)*

Transportation of radioactive materials in Georgia was studied for a second year, giving emphasis to surveying packages and vehicles, determining radiation exposure rates of workers, and enumerating and characterizing packages and vehicles. The survey of packages showed no significant radiation exposure or radionuclide contamination problems. Of 81 workers who were issued dosimeters, one half did not show exposures above background, but 10 workers had exposures between 0.5 and 5 R per year above background.

17. KEY WORDS AND DOCUMENT ANALYSIS

17a. DESCRIPTORS

17b. IDENTIFIERS/OPEN-ENDED TERMS

18. AVAILABILITY STATEMENT: Unlimited

19. SECURITY CLASS *(This report)*: Unclassified

21. NO. OF PAGES

20. SECURITY CLASS *(This page)*: Unclassified

22. PRICE: $

NRC FORM 335 (7-77)